Materials & Methods

Selection & use of

metals, nonmetallics, parts, finishes,

in product design & manufacture

September, 1956

Electrical Contact Materials—M & M Manual No. 130

Tailor-Made Ceramic Parts

How to Pick the Right Polyethylene

Sulfurizing Reduces Seizing

Cold Worked Stainless Takes 800 F

New Lacquer for Aluminum

How Cold Affects Nonferrous Metals

Complete Contents—page 1

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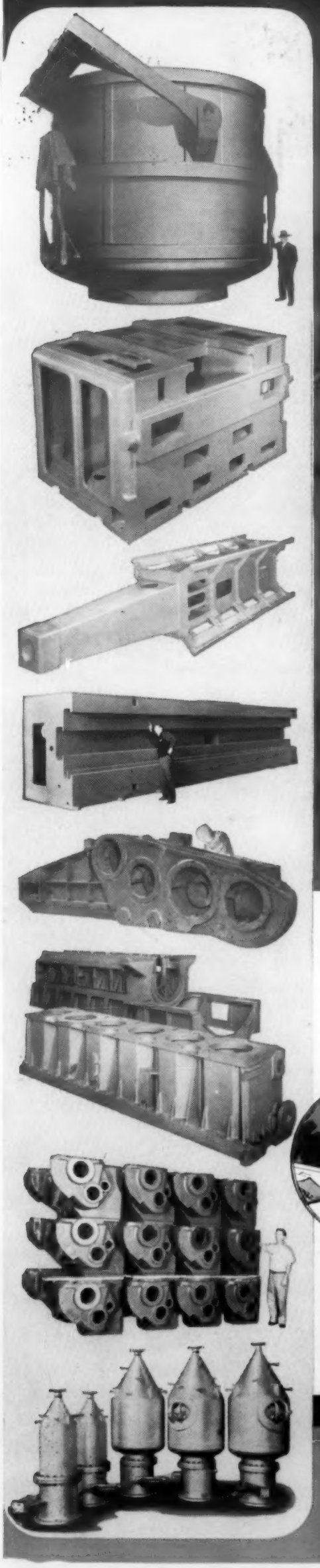

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Selection & use of

metals, nonmetallics, parts, finishes

in product design & manufacture

SEPTEMBER 1956 **VOL. 44, NO. 3**

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This wrought Inconel pot stayed hot eleven months, without failure

Think how this cuts salts bath operating costs

Neutral salt pots aren't usually expected to last 8000 hours. But carefully fabricated wrought Inconel* nickel-chromium alloy pots have.

Take *this* one. When the above photograph was taken it had been going for eleven months without shut-down. During this period it was operated at the customary 1500-1600°F, idled at about 1350F°.

The users, A. F. Holden Co., (Detroit Plant) had never previously used a wrought Inconel Alloy pot. So they're pretty enthusiastic about this one. It's brought their pot costs way down. And it's been a relief and a saving not to tear down the installation for frequent pot replacement.

Fabricated by Misco

Salt pots owe as much of their success to good fabrication as to the properties of the alloy used.

Recognizing this, the Holden Co. ordered this pot and, later, a stand-by successor from Misco Fabricators.

Misco skillfully formed and welded both under proper conditions . . . then X-ray inspected them.

You can ask a good deal of wrought Inconel alloy that has been properly fabricated. Not only for neutral salt pots but for most equipment subject to severe corrosive attack and prolonged high temperatures.

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Materials Outlook

MEDIUM DENSITY POLYETHYLENE is now being commercially produced in this country. Properties are similar to those of the material recently developed in England (see M&M, May '56, p 165). Produced by a modification of the conventional high pressure method, the polyethylene has a density of 0.935-0.940, with stiffness, heat resistance and other mechanical properties ranging between those of conventional polyethylene and those of high density polyethylene made by low pressure processes.

A HEAT RESISTANT LAMINATE combines the heat reflectivity of a bright metallic surface with the insulation characteristics of glass fabric-reinforced plastics. It affords an efficient barrier to heat transfer up to 1200 F. The highly reflective surface is produced by metallizing.

NUTS, BOLTS AND SCREWS CAN BE LOCKED together by means of a newly developed liquid sealant. The sealant, a thermosetting polymer, is a one-component material which has long shelf life and sets up only when present between mating metal surfaces in the absence of oxygen. When cured it keeps fasteners from shaking loose due to vibration, the break-loose torque being higher than the tightening torque.

ELECTROPLATING DEVELOPMENTS: 1) Alternating layers of electrodeposited nickel and chromium can be transformed into a homogeneous nickel-chromium alloy in about 4 hr by diffusion of the metals at 1800 F. Diffusion temperature is below the melting points of both metals. 2) Electrocladding molybdenum for oxidation resistance can be accomplished by plating a thin gold barrier over the first chromium plate. The gold prevents the molybdenum from diffusing through subsequent layers of chromium and nickel.

IMPROVED TITANIUM SHEET may result from two new alloy compositions now under development. The alloys, 3 Al-6% Mo and 4 Al-3% Mo, will be evaluated for use as flat rolled products in the solution heat treated and quenched condition.

NEW HEAT TREATING METHOD permits small precision stainless steel parts to be finish machined before heat treating. Not only do parts emerge bright and free from distortion, but the process can be used to produce controllable amounts of growth or shrinkage. The process, which involves special preparation and precise control of the furnace atmosphere, is reportedly effective for all hardenable grades of stainless.

MAGNETIC BONDING is reported to provide a method for joining dissimilar metals. The magnetic force causes molecules to interact and form

Materials Outlook

a bond. Metals can later be separated by reversing the magnetic field, neutralizing the bonding action.

GLASS DEVELOPMENTS: Thermal shock resistance — Clear silica glass has been developed that can be immersed red hot in ice water without damage. Melting point is high so the glass can be used continuously at 1800 F and intermittently up to 2500 F. Glass solders — Relatively soft glasses can be used to seal glass to metal at temperatures lower than possible with conventional glass-to-metal sealing techniques. Ferromagnetic materials — Binding carbonyl-type iron powders in a glassy matrix results in ferromagnetic materials of good permeability. Cores of this type are reported to have a low loss factor.

RECENT COMPARATIVE CORROSION TESTS on zinc and cadmium coatings indicated: 1) no difference between zinc and cadmium coatings in industrial environments particularly corrosive to zinc; 2) cadmium coatings have longer life in marine environments and warm humid atmospheres; and 3) rate of corrosion of zinc in coastal areas drops off rapidly as distance from ocean increases.

A TEMPERATURE RESISTANT PAINT capable of withstanding temperatures up to 1400 F without significant deterioration or loss of protective properties has been announced. Described as a ceramic frit-silicone resin type, the paint can be used to reduce accelerated oxidation of heated steel parts such as mufflers and manifolds on automobiles.

A HIGH PERMEABLE MAGNETIC MATERIAL is made by heating an alloy composed of 85 iron, 9.5 silicon and 5.6% aluminum at 930 F and rolling it at room temperature. As rolled, the alloy has triple its normal permeability, and eddy current losses are also considerably lower.

NEW STANDARDS: Plastics pipe — Standards covering dimensions and tolerances for rigid polyvinyl chloride pipe and solvent welded celluose actate butyrate pipe, proposed by the Society of the Plastics Industry, have been presented for consideration by industry by the Commodity Standards Div. of the Dept. of Commerce. Aluminum sheet — The Aluminum Assn. is adopting American Standard Assn.'s "Preferred Thickness for Uncoated Thin Flat Metals," as set forth in ASA B32.1-1952. The new standards apply to standard mill sizes for all aluminum alloy sheet sold through warehouses.

PRICE REDUCTIONS announced this past month: Titanium metal sponge — Du Pont reduced the price of sponge by 25¢ per lb. Grade A-1 sponge was reduced from $3.25 to $3; Grade A-2 from $2.95 to $2.70; and Grade A-2 fines from $2.55 to $2.30 per lb. Silicone rubber — Price reductions ranging from 5 to 20% on Silastic 161, 7-170, 7-181 and 8-164, together with 430 Gum and 432 Base, were announced by Dow Corning. Silicon — Du Pont cut the price of pure silicon $30 per lb, bringing the price to $350 per lb. A special grade of silicon suitable for use in solar converters was made available at $180 per lb.

Men of Materials...

Stephen Palinchak, Assistant Chief of the Rubber and Plastics Div., Battelle Memorial Institute, has been active in the design and development of rubber products. Dr. Palinchak has also been associated with the Seamless Rubber Co. and with the Rubber Research Program at Akron University. During World War II he developed a process for fabricating vinyl parts for the military.

Palinchak says:

"Rubber can be tailored to meet a variety of engineering specifications."

"During the time that rubber was under Government control, there were only a few characteristic types of rubber. Plastics, on the other hand, were large in variety and a fabricator could choose a plastic to suit his purpose.

"Today, with the rubber industry in private hands, there are improvements in GR-S, neoprene, Thiokol, nitrile and polyacrylic rubbers. The British, pushed by synthetic rubber developments, have modified natural rubber to produce many interesting products with unusual properties. For example, monochlorothiol acetic acid-treated rubber is claimed to give an oil resistant rubber equal to polychloroprene. New rubber developments in the United States have produced rubbers for a great variety of engineering applications.

"Rubber has teamed up with plastics for the production of rubber and plastics items having properties that cannot be obtained by plastics or rubber alone. Through polymer blends and graft polymerization, high impact materials such as high impact styrene and acrylonitrile polymers have been prepared. Higher strength silicone rubbers have become available through mixtures with fluorocarbon resins. Phenolic-nitrile rubber blends and polyvinyl chloride-nitrile rubber blends have produced many products of high strength and abrasion resistance.

"There is no end in sight at present for rubber and plastics demands. Eventually, it will be difficult to determine what constitutes a rubber or plastics product, and specific definitions will be required to distinguish one from the other."

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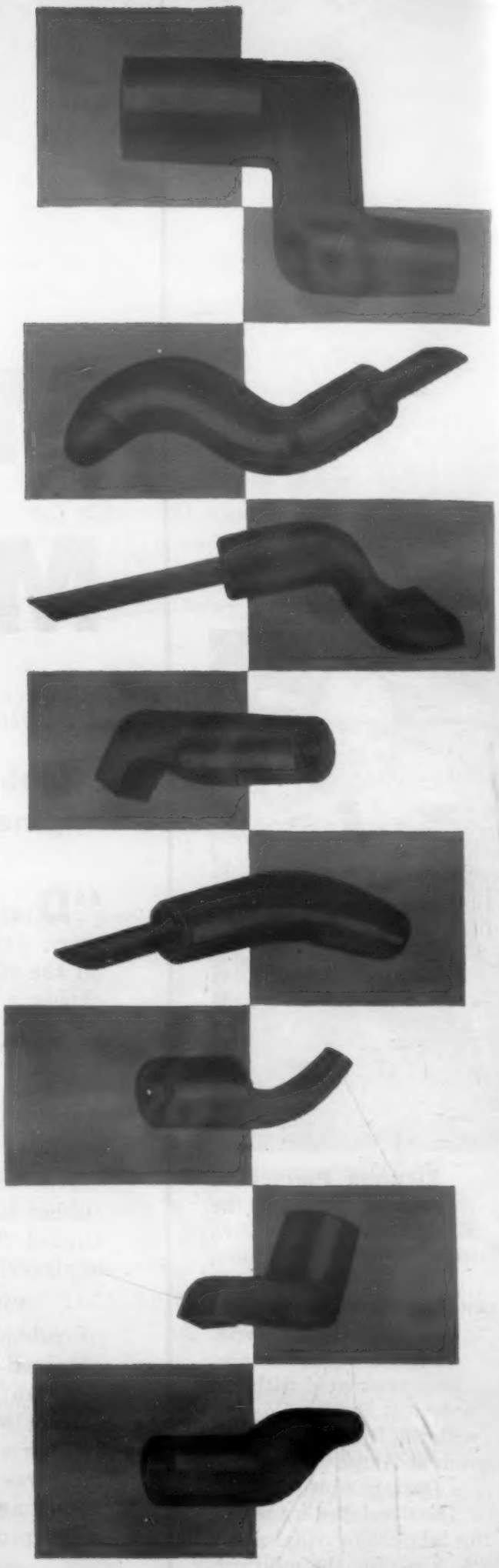
*Patent No. 2,489,993.



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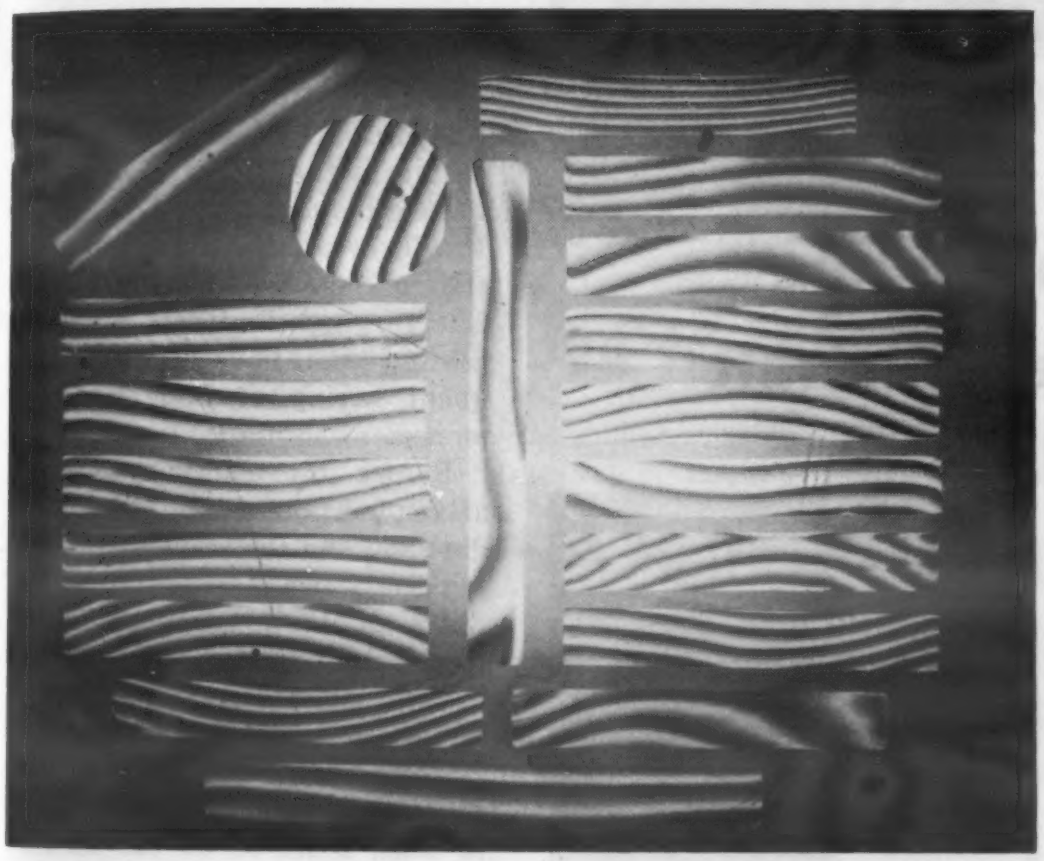
MATERIALS ENGINEERING NEWS

This month

- *Materials certification*
- *Largest aluminum forging*
- *Predesigning alloys*



***Millionth of an inch** flatness of the circular object (upper center) is revealed by the straight light wave pattern, called a light fringe, running across the diameter of the glass part. The rectangular pieces are high precision steel gage blocks showing a wavy light pattern. Each dark band is 0.000011 in. from center to center. Discrepancies are determined by drawing a straight line across the center of each light fringe. In this case the steel blocks are shown to be more than one light fringe in error.*

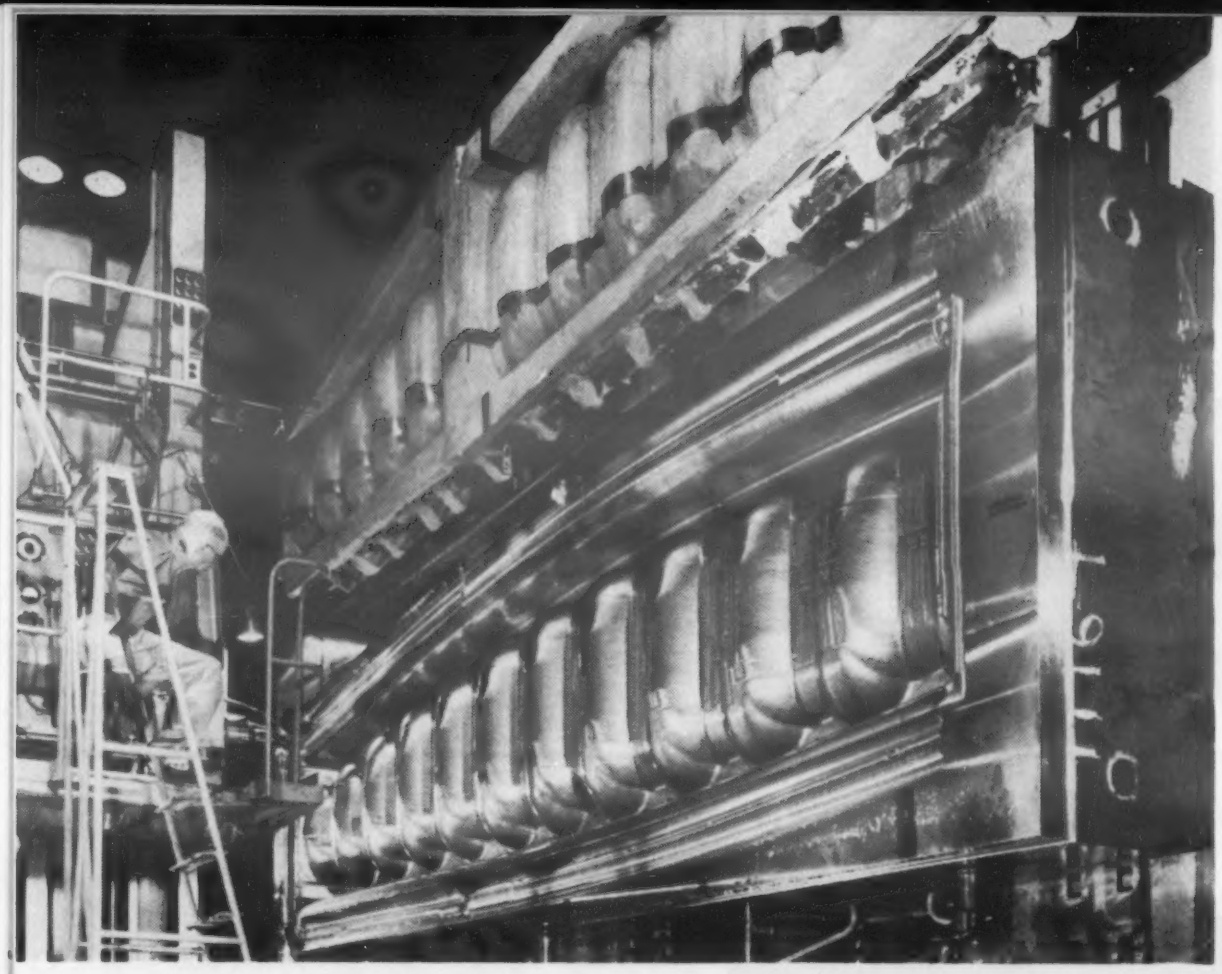
'Light fringes' check finish of guided missile parts

Surface Flatness Measured with New Precision

■ Surface finishing of materials has entered another era of precision. With the advent of the intercontinental missile, Northrop Aircraft, Inc. has found that ordinary precision standards cannot insure the reliability of these defense weapons.

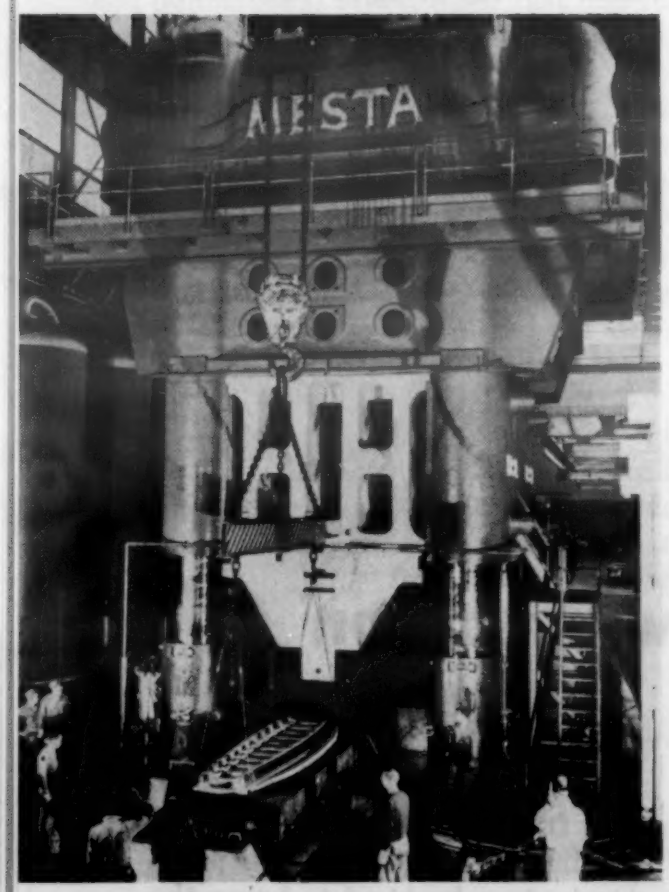
Company engineers now reckon surfaces in terms of light fringes. A light fringe equals 0.000011 in. and many of the instruments manufactured by the company are held within a tolerance of 0.1 of a light fringe.

Delicate finishing of the products is done by hand to bring the components to their final peak of precision. Final finishing step is done by skilled technicians on flat or spherical metal lapping plates.



***Sinking the world's largest** closed die at Alcoa's Cleveland Works took approximately 1500 manhours per die half. Completed die weighs 30 tons.*

Largest Aluminum Forging Is Backbone of New Aircraft



***Aluminum forging,** a 3000-lb section for the multi-jet Martin XP6M Sea Master, is removed from the 50,000-ton press in the Air Force plant in Cleveland.*

***Completed aluminum forging** is 156 in. long, 36 in. wide and 12 in. thick. It will help form the backbone of the fuselage and wing structure of the new jet seaplane.*

■ The largest closed die aluminum forging ever made was recently produced on the Air Force's giant 50,000-ton press in Cleveland. Weighing 3000 lb the completed forging measured 13 ft in length, 3 ft across at its widest point, and a foot in thickness. The forging will be part of the airframe in the XP6M Sea Master, the world's first multi-jet seaplane. It will help form the backbone of the fuselage and wing structure. The forging eliminates numerous joining operations with a consequent saving of both time and money.

Before the forging could be attempted, the Cleveland Works' die shop had the problem of sinking the world's largest dies. Because of their exceptional size, the plaster models had to be made in two sections to minimize distortion.

From a set rough forged, armor plate steel die blocks weighing 75 tons, a set of 60 ton finished dies was produced. Some 15,000 lb of metal were machined from the blocks prior to mounting on the die sinking equipment. The remainder was whittled away during the actual sinking operation and in the milling of key and toe clamp slots. Engineering and production of the dies required several months, with sinking and finishing operations for each die consuming 1500 man hours.

The huge press squeezed the big forging from a 4200-lb blank in alloy X7079. This high strength alloy can be heat treated to high mechanical properties not previously possible in heavy sections.

Materials Certification Plan Gets Mixed Reception

■ Industry opinions are varied on the feasibility of establishing a cooperative agency to certify the quality of materials. The proposal for such an agency with specific reference to the aircraft industry was made by Charles M. Miller, materials engineer at Northrop Aircraft, in a paper delivered at the SAE Golden Anniversary Meeting in New York. (See M&M, June '56, p 111.)

Miller's proposal was subsequently circulated among various suppliers of aircraft materials for their comment. Although many people in the industry indicated the need for a materials qualification agency, they held the reservation that the time involved in processing individual testing might be a disadvantage. Others flatly rejected the idea, stating that no outside agency could relieve the producer from his responsibility to test and thus insure the quality of his own product.

Typical opinions included:

▸ "Testing procedures, materials, and components are not sufficiently standardized in the aircraft industry to permit such an agency to be effective. In our opinion, this agency would not achieve acceptance by either producers of materials and components or consumers of these items. Direct contact between producers and consumers is vital to producing quality aircraft and an intermediate agency would tend to prevent this liaison and inhibit progress rather than promote it."

▸ "Believe the basic principle of having the agency answerable to the supplier rather than to the purchaser is basically wrong. Any commercial laboratory can now furnish this service."

▸ "If properly accepted, it might improve quality and reduce red tape."

▸ "Considering industry as a whole there is a definite need."

The survey of industry was done independently by Mr. Miller, for use as a basis for further study. According to Mr. Miller, the proposed agency might function in the aviation field in a manner similar to the activity of the Underwriters Laboratory in the electrical and safety fields. It would be used voluntarily by industry to assure greater aviation safety.

Predesigning Alloys for Engineering Applications

■ Engineers and designers may soon be able to specify what property combinations are needed in a particular alloy with assurance that the alloy will be provided in a minimum amount of time. Metallurgists are now on the threshold of predesigning a needed set of properties into an alloy eliminating the time consuming cut-and-try metallurgical methods usually employed.

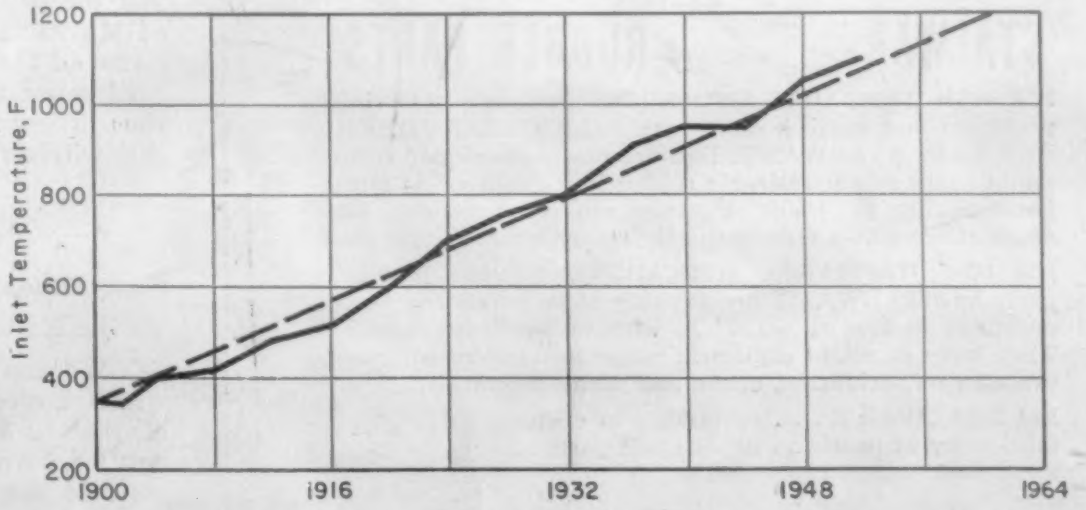
Key to this new research technique is metallurgy's transition from an inductive science to a deductive one. Walter R. Hibbard, Jr., Manager of Alloy Studies Section of the General Electric Research Laboratory, recently pointed out that "the rapidly developing store of knowledge in the various alloy types can be utilized directly to obtain desirable structures. For example, in the high temperature superalloys, the optimum degree of solid solution hardening, the optimum grain size, the optimum distribution of particles along the grain boundaries and within the grains are sought. The next step is to select the optimum combination of an alloy system and processing to obtain the desired structure most economically. Combinations of these technologies and pilot plant experience should produce new and useful alloys tailored to the new and important applications of the present and future."

Alloy designing

Paper and pencil metallurgists are already at work cutting down on the number of laboratory tests necessary to find the right alloy for a specific application. The latest development utilizing this new research technique of "predesigning" was recently announced by Westinghouse Electric Corp.

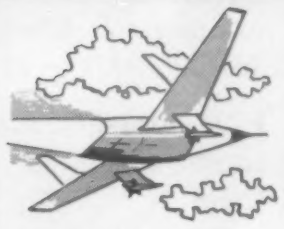
Starting with the conditions under which a turbine blade must

(continued on p 246)



***Forecast of metallurgical** problems is shown by the yearly rise in steam inlet temperatures of steam turbines. Alloys must be designed to meet these operating conditions.*

if you design for...



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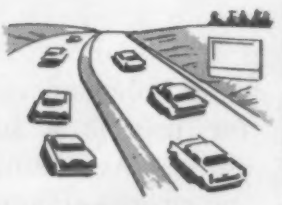

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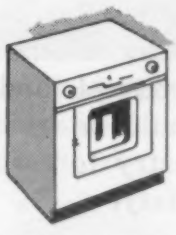

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LETTERS TO THE EDITOR

Coatings for steel

To the Editor:

I would like more information about the relative corrosion resistance of various coatings on steel. In particular, I am looking for a combination coating that has good corrosion resistance along with resistance to abrasion. Would it be possible to obtain tables of values for corrosion resistance and for abrasion resistance for various coatings? . . .

HAROLD COSSON, Development Engineer
Wright Saw Div.
Thomas Industries, Inc.
Fort Atkinson, Wis.

As far as we know such tables do not exist in any comprehensive form. It's a good idea, though, and we will try to do something about it.

Battery additive fiasco

To the Editor:

I certainly want to express my appreciation for the thoughts expressed in the June editorial of MATERIALS & METHODS. In particular, the statement: "Their testimony was not based on controlled engineering tests. It was merely their personal opinion" should have been underscored and printed in capital letters.

It seems most unfortunate that engineers and scientists are such poor salesmen of the merits of their profession. Politicians, most of whom have no appreciation of ethics or conscientiousness, somehow should be made to understand that engineers and scientists follow the same code of ethics as the medical profession.

H. T., Metallurgical Engineer

To the Editor:

The engineering and chemical professions salute you for your courageous editorial in the July issue of MATERIALS & METHODS. The recent flaunting decision of the FTC in the battery additive case is indeed cause for alarm and it is my hope that a further review will distill some measure of justice from this witches brew.

GEORGE KAHN
Boston, Mass.

Sometimes our left hand . . .

To the Editor:

We were dismayed by the following statement which appeared on page 94 of the July issue of MATERIALS & METHODS in connection with the article entitled "Anodized Coatings for Aluminum" in the inserted box headed, "Some Process Details": "Also, the rack must be constructed from aluminum since other metals will dissolve in the electrolyte."

We should like to point out that your recent issues have carried two references to the use of titanium for anodizing racks. First, our own article, "Where Industry is Using Titanium and Saving

(continued on p 298)

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Students and foreign subscribers (other than Canadian), please request literature directly from manufacturers.

MANUFACTURERS' LITERATURE

New Literature

Colored Stitching Wire. Acme Steel Co., 1 p. Selection guide for colored stitching wire. Colorstitch has a tough vinyl paint finish that resists chipping and peeling. (1)

Precision Parts. Aero Supply Mfg. Co., Inc., 8pp, illus. Describes facilities for design and production of precision parts on contract basis. Lists work and size capacities and shows sample varieties. (2)

Tool and High Speed Steels. Allegheny Ludlum Steel Corp., 16 pp, illus. Expanded edition of "The Working of Tool and High Speed Steels." Contains 17 charts with detailed information. (3)

Brazing Rings. Alloy Ring Service, Inc., leaflet, illus. How to lower your costs, speed production and increase quality with precision rings and brazing preforms. (4)

Aluminum Design Manual. Aluminum Co. of America, 32 pp, illus. Describes Alcoa impacts and their method of fabrication—impact extrusion. Process produces hollow cup-shaped shells, flanged or cupped-end tubes, solid shapes and combinations of these forms at high production speeds and low cost. (5)

Heat Resistant Castings. American Brake Shoe Co., Electro-Alloys Div., 16 pp, illus., No. T-225. How properties of Thermalloy make it advantageous for castings used in heat treating applications. Describes facilities and engineering service and shows typical applications. (6)

Forged and Rolled Rings. American Locomotive Co., 16 pp, illus., Nos. SF-1, SF-2. Describes advantages and applications of seamless forged and rolled rings. (7)

Beryllium Copper. American Silver Co., Inc., 4 pp, No. A-300. Data sheet features details on specific methods for heat treating beryllium copper. (8)

Bronze Electrodes. Ampco Metal, Inc., 4 pp, illus., No. W-25a. Applications, characteristics, properties and sizes of Ampco-Trode electrodes, both a.c. and d.c.; Phos-Trode; Ampco-Trode Filler Rod and Coiled Wire; and Ampco-Braz No. 1 and 3. (9)

Aluminum Alloys. Apex Smelting Co., 15 pp, illus. Composition, typical mechanical properties and heat treatments of standard Apex aluminum alloys. (70)

Spring Design. Associated Spring Corp., 8 pp, illus. Current issue of *The Mainspring* contains "Relative Load Change of Compression and Extension Springs Due to Certain Dimensional Variations." (10)

Shell Cast Copper Alloys. Aurora Metal Co., 6 pp, illus. Describes the shell mold process as applied to copper base alloy castings. Lists advantages and shows typical applications. (11)

Subzero Pressure Tubing. Babcock & Wilcox Co., Tubular Products Div., 6 pp, illus., No. TB-357. Information on tubular products for subzero applications such as ethylene purification, low temperature heat treatment of tool steels and synthetic rubber production. (12)

Gray Iron. Belle City Malleable Iron Co., 4 pp, illus. Lists ten reasons for Belectric Iron's superiority. This gray iron is not poured into molds as tapped from cupola, but goes into an electric furnace for further purifying. (13)

Beryllium Copper. Beryllium Corp., 12 pp, illus. Shows range of Berylco beryllium copper casting alloys: available alloys, properties, advantages, casting and processing techniques. (14)

Alloy Tubing. J. Bishop & Co. Platinum Works, Stainless Steel Products Div., 12 pp, illus. Catalog of cold drawn stainless steel tubing—mechanical, capillary and hypodermic—from 0.008 to 1 in. o.d. Also describes nickel and nickel alloy tubing and small tubular specialties. (15)

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Teflon Products. Continental-Diamond Fibre Co., Div. of Budd Co., Inc. 16 pp, illus., No. T-55. Catalog of Teflon tubes, sheets, rods, gaskets and fabricated specialties. (16)

Bendable Tubing. Flexaust Co., Div. of Callahan Zinc-Lead Co., Inc., 4 pp, illus. No. 61. Describes Plica, a bendable tubing that can be bent by hand, cut with hacksaw or knife. Made in ferrous and nonferrous metals, fiber, paper and other materials, it is used for electrical conduit, air ducts, shaft casing and noncorrosive liquid lines. (17)

Finned Tube. Wolverine Tube Div., Calumet & Hecla, Inc. Booklet covers the numerous applications for Trufin integrally finned tube in the processing, electrical, water heater, refrigeration and allied industries. (18)

Fasteners. Camloc Fastener Corp., 6 pp, illus., No. 53. Lists advantages of Camloc fasteners. Originally developed for aircraft where extreme vibration occurs, these fasteners are used in other industries because they "open or close in a split second with positive locking action." (19)

Rivets. Chicago Rivet & Machine Co., 16 pp, illus., No. 42. Catalog lists almost 1400 standard precision-made semitubular, full tubular and split rivets, and bag studs and rivet caps. Also contains chart of standard clinch allowances that shows how to determine proper rivet length. (20)

Chromizing Steel Surfaces. Chromalloy Corp., 8 pp, illus., No. 5. Describes Chromalloy process for increasing the heat, wear and corrosion resistance of steel by high temperature diffusion of chromium into the surface. (21)

Colorants for Polyethylene. Claremont Pigment Dispersion Corp., 6 pp, No. 220. Data on the PE series of granular color concentrates for coloring polyethylene. (22)

Screws. Cleveland Cap Screw Co., Box 888, 2917 E. 79th St., Cleveland 4, Ohio. Vinyl plastic card listing steel analysis, head marking, tensile strength, Brinell and Rockwell hardness for screws up to 2½ in. dia. Request from Advertising Manager, Cleveland Cap Screw Co.

Cleaner. Cobehn, Inc., 8 pp, illus. Describes the Cobehn Spray-Clean Technique used for cleaning precision ball bearings in gyros, servomechanisms and other instruments where low torque specifications must be met. (23)

Springs and Formed Wire. Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div., 12 pp, illus. Shows various types of Wickwire springs and formed wire, including compression, extension, torsion and flat wire springs. (24)

Glass. Corning Glass Works, 12 pp, illus., No. IZ-1. Stresses increasing importance of glass in product design, tabulates physical characteristics of various glasses and describes design services. (25)

Teflon Products. Crane Packing Co., 12 pp, illus., No. T-110. Facts on Chemlon, John Crane products made from Teflon. Describes mechanical and hydraulic packings in both braided and molded types, special hydraulic packings, FreeFlow envelope type and solid gaskets, O-rings, flexible bellows and sheet, rod, tubing and tape. (26)

Silicone-Glass Laminates. Dow Corning Corp., 4 pp, illus. Features a wide range of specific electrical and electronic applications for silicone-glass laminates. Lists physical and dielectric properties. (27)

Alloy Handbook. Wilbur B. Driver Co., 150 pp., illus. "Alloy Handbook of Electrical Resistance and Electronic, Chemical and Mechanical Applications." A complete manual that is an excellent introduction to this company's alloys, technical services, plants and facilities. (28)

Electronics. Driver-Harris Co., 8 pp, illus. Four bulletins describe a 0.0005-in. dia enameled wire for resistors; an alloy with a specific resistance of 1000 ohms per cmf; a new heating element alloy; and a new oxidation resistant, thermocouple for high temperatures. (29)

Large Forged Nuts. Jos. Dyson & Sons, Inc., 5125 St. Clair Ave., Cleveland 3, Ohio. Catalog of large hex nuts, square nuts and special nuts ranging in size from 1¾ to 8 in. Request from Dyson, Dept. P.

Plasticizer. Eastman Chemical Products, Inc., 6 pp. Describes plasticizer 84, a distilled butyl octyl phthalate plasticizer that shows promise as a replacement for dibutyl phthalate in nitrocellulose lacquers. Laboratory tests show new plasticizer to have excellent cold check resistance and permanence. (30)

Custom Molded Plastics. Erie Resistor Corp., Plastics Div., 4 pp, illus. Describes facilities for custom molding plastics and shows typical products. (31)

Welding Procedures. Eutectic Welding Alloys Corp., 140 pp, illus. Pocket data book containing welding procedures for every base metal. Covers 120 welding rods, electrodes and welding compounds. (32)

Aluminum Parts. Falstrom Co., 2 pp, illus., No. 140-20M-54. Describes facilities for fabricating aluminum parts and shows typical products. (33)

High Impact Plastics. Fiberite Corp., 4 pp, illus. Describes largest producer of reinforced phenolic and melamine molding compounds, gives properties of various Fiberite materials and shows applications. (34)

Paint Wiping, Spraying. Finish Engineering Co., Inc., 4 pp, illus. Data on an automatic paint wiper that handles 1000 parts per hr and a spray painting machine that paints as many as 1200 pieces per hr. (35)

Sintered Carbides. Firth Sterling, Inc., 4 pp, illus. Describes Firthite TXL, a carbide grade for machining steel. Contains a cutting speed vs tool life graph and performance reports. (36)

Cementable Teflon Tape. Garlock Packing Co., 2 pp, illus., No. AD 158. Data and installation instructions on cementable Teflon tape in thickness as low as 0.005 in. (37)

Powdered Metal Electrodes. General Electric Co., Welding Div., 4 pp, illus., No. GED-3048. Weld properties, deposition rates and other characteristics of low hydrogen, powdered metal electrodes Strikeasy LH-1 and LH-2. (38)

Rigid PVC. B. F. Goodrich Chemical Co., 8 pp, illus. How rigid unplasticized polyvinyl chloride compounds Geon 8700-A and 8750 are used in making rigid vinyl pipe and fittings. (39)

Cast Iron Specifications. Gray Iron Founders' Society, Inc., 4 pp. "Summary of Cast Iron Specifications." Covers gray and nodular (ductile) cast irons and cast pressure pipe, soil pipe, valves and fittings. (40)

Silver Brazing Alloys. Handy & Harman, 4 pp, illus., No. 70. Applications of Easy-Flo and Sil-Fos low temperature silver brazing alloys. (41)

Perforated Materials. Harrington & King Perforating Co., Inc. 128 pp, illus., No. 62. Catalog of perforated metals and other sheet and plate materials. Lists advantages, shows standard patterns, gives instructions for ordering and suggests new industrial and decorative uses. (42)

Arc Welders. Harnischfeger Corp., 4 pp, illus., No. W99-1. Describes a.c.-d.c. arc welders that are simple, safe and automatic. They are suitable for metallic arc, Heliarc, sigma and spot gun welding. (43)

High Density Polyethylene. Hercules Powder Co., Cellulose Products Dept., 6 pp. Properties and uses of Hi-fax, a new high density polyethylene made by the Ziegler process. (44)

Socket Screws. Holo-Krome Screw Corp., 32 pp, illus. Industrial consumer net price schedule for cold forged socket screw products. (45)

Sleeve Bearings. Johnson Bronze Co., 4 pp, illus. Advantages of Johnson's standard sleeve bearings made in more than 900 sizes and more than 200 combinations. Tabulates tolerances and chemical and physical properties. (46)

Cemented Carbides. Kennametal, Inc., 44 pp, illus., No. B-222. "Designing with Kennametal" provides mechanical design information for engineers who design parts calling for the use of Kennametal or Kentanium. (47)

Molded Fiberglass. H. Koch & Sons, 20 pp, illus. Shows facilities of one of the world's largest fabricators of molded Fiberglas products. Among other equipment, Koch makes carrying cases for delicate instruments, all-weather radomes and luggage. (69)

Welding Electrodes. Lincoln Electric Co., 28 pp, illus., No. SB-1352. Guide for selecting electrodes for stainless steels, nonferrous metals, cast iron and manual hardsurfacing. (48)

Printing and Marking. J. Frank Motson Co., 4 pp, illus. Describes specialized services in printing and marking on plastics, glass, metals, wood, ceramics and other materials. (49)

Manufacturers' Literature

Reduced Iron Powder. National-U. S. Radiator Corp., Plastic Metals Div., 4 pp. Properties of Plast-Iron Grade B-261 used in the making of sintered compacts. The reduced iron powder eliminates copper, saving from 1 to 5¢ per lb in cost of material. (50)

Vulcanized Fibre, Laminates. National Vulcanized Fibre Co., 4 pp, illus. Properties and uses of vulcanized fibre, a converted cotton cellulose, and Phenolite laminated plastics, a group of thermosetting high pressure laminates. (51)

Wire Cloth Parts. Newark Wire Cloth Co., 8 pp, illus. Describes facilities for making wire cloth parts and assemblies. Also shows typical wire cloth inserts and assembled wire cloth parts in fine, medium and coarse mesh and space cloth. (52)

Reinforced Plastics. Owens-Corning Fiberglas Corp., Plastics Reinforcement Div., 28 pp, illus., No. PR6 A1. How Fiberglas-reinforced plastics reduce production costs and build product sales. Gives properties of various reinforcing materials and of parts made from reinforced molding compounds. (53)

Self-Clinching Fasteners. Penn Engineering & Mfg. Co. 12 pp, illus., No. CL-356. Design information, installation directions and recommended forces for Pem self-clinching nuts for load carrying threads in thin steel, brass, copper or aluminum sheets. Nuts are installed in drilled or punched holes with standard tools. (54)

Heat Resistant Paints. Preferred Utilities Mfg. Corp., 12 pp, illus. Data on Preferred White Hot, a white paint that contains titanium and resists temperatures to 2840 F, and Preferred Pyro-Chrome, a green paint with a chrome base, that resists heat to 4000 F. (55)

Barrel Finishing. Almco Div., Queen Stove Works, Inc., 50 pp. illus. Comprehensive manual divided into four sections: barrel finishing and variables involved; Almco sample processing laboratories; Supersheen barrel finishing machines and accessory equipment; Supersheen media and finishing compounds. (56)

Teflon Products. Raybestos-Manhattan, Inc., Plastic Products Div., 8 pp. Typical applications properties and sizes of Teflon and Raylon (reprocessed Teflon) sheets, tape and molded and extruded rods and tubes. (57)

Aluminum Digest. Reynolds Metals Co., 2500 S. Third St., Louisville 1, Ky. *Reynolds Aluminum Digest* contains 50 to 60 reviews of articles relating to aluminum a news summary of related current events, statistics on the aluminum industry and patent listings. To receive this monthly, request from Reynolds, Desk ES.

Silver and Nickel Plating. Sel-Rex Precious Metals, Inc., 16 pp. Describes Silvrex bright silver plating process said to give a mirror bright finish directly from the bath, either as a flash or as a heavy deposit. Also explains Lectro-Nic process for depositing hard, ductile, comprehensively stressed nickel coatings. (58)

Quarter-Turn Fasteners. Southco Div., South Chester Corp., 12 pp, illus. Catalog on Lion fasteners. Describes three main types of quarter-turn fasteners and their applications. (59)

Nickel and Nickel Alloy Tubing. Superior Tube Co., 20 pp, illus., No. 12. Catalog of nickel and nickel alloy tubing. Tabulates mechanical and chemical properties and discusses selection and application. (60)

Friction Materials. Thermoid Co., 76 pp, illus. Catalog contains fundamental information on friction materials, including a chart to aid in proper selection to meet various requirements. (61)

Rivet. Cherry Rivet Div., Townsend Co., 4 pp, illus. No. TCL-112. Advantages and operating principles of the Cherry "700" rivet. Lists head styles, diameters and lengths. (62)

Extruded Teflon Rod. Tri-Point Mfg., Inc., 1 p, No. T-556. Price schedule on extruded Teflon rod in 22 diameters from 0.125 to 1 in. (63)

Compression Formed Tubing. Tube Reducing Corp. 6 pp, illus., No. R3. Reprint: "Compression-Formed Steel Tubing Offers Close Tolerances and High Strength Properties." (64)

PVC Parts. Tube Turns Plastics, Inc., 6 pp, illus. How custom molded parts of unplasticized polyvinyl chloride solve corrosion and weathering problems. Tabulates PVC's resistance to various materials and shows representative products. (65)

Plastics Primer. Bakelite Co., Div. of Union Carbide & Carbon Corp., 48 pp, illus. "The ABC's of Modern Plastics" presents basic facts on the sources and production of plastics, their spectacular growth and their importance. (66)

Copper Powder. Malone Metal Products, subsidiary of U. S. Bronze Powder Works, Inc., 4 pp, illus. Describes Fernlock Copper, which is made by electrolysis and has a dendritic particle shape, low density, fine mesh size and high purity. (67)

Perforating Dies. S. B. Whistler & Sons, Inc., 24 pp, illus., No. 55. Catalog of adjustable perforating dies. Lists sizes, shapes, applications and punching pressures. (68)

Other Available Literature

Irons & Steels • Parts • Forms

Malleable Iron. Albion Malleable Iron Co., 15 pp, illus. A thorough analysis of malleable iron. Defines malleable iron and shows its relationships to other ferrous materials. Also presents micrographs, physical properties and relative cost figures for several parts now being manufactured. (74)

Stainless Steel Powders. Alloy Metal Powders, Inc. Concerns sintering of high temperature alloy powders in the stainless steel group and the availability of such grades. (75)

Alloy Steels. Armco Steel Corp., 32 pp, illus. Graphic description of quality control from raw material to finished steels. (76)

Wire Parts, Small Stampings. Art Wire & Stamping Co., 4 pp, illus. Shows a variety of wire parts and small metal stampings produced in both ferrous and nonferrous metals. (77)

Investment Castings. Austenal Laboratories, Inc., 12 pp, illus. Describes Microcast process and charts representative properties of investment cast alloys. (78)

Forged Steel Rings, Flanges. Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., 12 pp, No. 10,000. Design advantages and cost-cutting applications of forgings in industrial processing equipment. (79)

Nickel Plated Steel Pipe. Bart Mfg. Corp., 6 pp, illus. Lectro-Clad pipe controls corrosion in water systems, in natural gas production and in the pulp and paper organic chemical and inorganic chemical fields. (80)

Low Alloy Steel. Bethlehem Steel Co., 66 pp, illus., No. 353. Properties and features of Mayari-R steel for use in applications requiring high strength and good wear and corrosion resistance. (81)

Wire Cloth. Cambridge Wire Cloth Co., 4 pp, illus. New quarterly house organ on woven wire conveyor belts, industrial wire cloth and other woven wire products. (124)

Circular Steel Parts. Cleveland Welding Co., 26 pp, illus. Describes Cleve-Weld Process and shows how specialized facilities and know-how can save money on circular steel parts. (82)

Steel Tubing. Summerill Tubing Co., Div. Columbia Steel & Shafting Co., 8 pp, illus. Cold drawn steel tubing for hydraulic applications. (83)

Circular Steel Shapes. Commercial Shearing & Stamping Co., 24 pp, illus., No. P-3. Covers range of cold formed circular steel blanks, flanged and dished shapes, produced from stock dies. (84)

Stainless Steel Castings. Cooper Alloy Corp., 8 pp, No. 55. Information on cast stainless steels includes mechanical properties and extensive corrosion data. (85)

Perforated Steel Sheets. Cross Engineering Co., leaflet, illus. Shows variety of designs available and typical uses of perforated steel sheets for ventilation, concealment, decoration and protection. (86)

Stainless Steel Fabrication. Crucible Steel Co. of America, 160 pp. Fabricator's handbook for Rezistal stainless

steels. Forming, machining, cutting, joining, heat treating, pickling, finishing and other reference data. (87)

Forging Information. Drop Forging Assn., 8 pp, illus. Booklet describes forging process and uses of method in everyday products. (88)

Static and Centrifugal Castings. Duraloy Co., 16 pp, illus., No. 3354-G. Describes facilities for producing high alloy static and centrifugal castings. Data on castings for heat, corrosion and abrasion resistance. (89)

Iron Powder. Easton Metal Powder Co., Inc., 5 pp, illus. Specifications for designing with Ferroflame "A" iron powder. (90)

Investment Castings. Engineered Precision Casting Co., 8 pp, ilus. Complete data on EpCo precision investment castings of stainless steel, alloy tool steel, beryllium copper and other metals and alloys. (91)

Inserts. Groov-Pin Corp. Self-tapping insert used as original equipment and for salvage and repair of stripped threads. (92)

Steel Extrusions. H. M. Harper Co., 16 pp, illus. Covers production of extrusions from stainless steels, heat resistant alloys, titanium alloy steels, carbon steels and specialty bronzes. Glass lubricant assures inexpensive dies, rapid die changes and economical extrusion of difficult alloys. (93)

Steel Tubing. Higby Mfg. Co., Avon Tube Div., 8 pp, illus. Fabrication and application data for thin walled steel tubing. (94)

Powder Metal Parts. Keystone Carbon Co., 6 pp. folder. Describes powder metal products and production facilities. (95)

Wire. Keystone Steel & Wire Co., 12 pp, illus., No. 1a Ke. Illustrates the various kinds of wire available and provides information about the cold heading operation. (96)

Steel Bar. La Salle Steel Co., 20 pp, illus. Data and charts on properties of a high strength, free machining bar. (97)

Carbon and Alloy Steels. Lukens Steel Co., 12 pp. Compares carbon and alloy steels for pressure vessels. Nine graphs show temperature limitations. (98)

Castings. Meehanite Metal Corp., 4 pp, illus. Reprint tells how cost of special pattern making can be eliminated by ordering cast bar stock in standard sizes. (99)

Forgings. Pittsburgh Forgings Co., 4 pp, illus. Pictures forgings made for the automotive industry. (100)

Seamless Mechanical Tubing. Pittsburgh Steel Co., 198 pp, illus. Applications, cost anlaysis, production techniques, inspection and testing methods. tolerances, chemical composition, physical properties, machining techniques, reference tables for full range of seamless mechanical tubing. (101)

Deep Drawn Parts. Pressed Steel Tank Co., 16 pp, illus. How industries have been helped in quality production at low cost by use of Hackney Metal containers and deep drawn component parts. (102)

Roll Formed Shapes. Roll Formed Products Co., 26 pp, illus. Shows simple and complex sections produced from both ferrous and nonferrous metals. (103)

Steel Tubing. Sawhill Tubular Products, Inc., 16 pp. Information on grades and size range of company's steel tubing. (104)

Zinc Coated Steel. Sharon Steel Corp., 12 pp, illus. Physical properties of a hot dipped, zinc coated strip steel. (105)

Steel Castings. Steel Founders' Society of America, 4 pp, illus., Product Design Study No. 71. How a complex one-piece compressor cylinder was cast in steel. (106)

Embossed Steel. Sun Steel Co., 4 pp, illus. Patterns available in embossed steel sheets and coils. (107)

Wire Processing. Sylvania Electric Products, Inc., Parts Div., 12 pp, illus. Facilities for manufacture of fine wire and ribbon, and wire and ribbon parts. Chemical composition charts of materials used are included. (108)

Steel Castings. Tempil Corp., 40 pp. "Recommended Practice for the Welding of Steel Castings." Comprehensive manual published by the Steel Founders' Society of America. (109)

Steels. Timken Roller Bearing Co., Steel & Tube Div., Canton, Ohio. Complete catalog of steels. Request from Timken on company letterhead.

Small Precision Metal Parts. Torrington Co., Specialties Div., 4 pp, illus. Shows various small precision metal parts custom-made by this company. (110)

Seamless Steel Tubing. Tube Reducing Corp., 4 pp, illus. Data on Rockdrawn small diameter, seamless steel tubing. Sizes range from ⅛ to 1⅜ in. o.d. in a wide variety of wall thicknesses in carbon, alloy and stainless steel. (111)

Steel Castings. Unitcast Corp., illus., No. 649A. Discusses testing facilities for insuring high quality production of steel castings. (112)

Constructional Alloy Steel. U. S. Steel Corp., illus. "U. S. Steel Presents T-1" gives properties and fabrication data for new high strength, weldable steel with exceptional toughness. (113)

Weldment Fabrication. Acme Welding Div., United Tool & Die Co., 6 pp, illus. Describes facilities for planned weldment fabrication. (114)

Vacuum Melting. Utica Metals Div., Utica Drop Forge & Tool Corp., 8 pp, illus. Production and testing equipment. and progress made by Utica in taking vacuum melting out of the laboratory and into production. (115)

Tool Steel. Vanadium-Alloys Steel Co., 68 pp. New tool steel guide with data on more than 50 types of tool steel and cold finished products. (116)

To obtain literature listed on these pages, use the convenient prepaid post card on pp 67 and 68.

Stampings. WLS Stamping Co., 4 pp illus. Describes high speed, low cost stamping process using "speed tooling" method. (117)

Pipe and Tubing. Wallingford Steel Co., 8 pp, illus. Stainless, carbon and alloy steel tubing for ornamental, mechancial, pressure, sanitary and aircraft use in size range from ¼ to 3 in. o.d. (118)

Stainless Steel Sheet. Washington Steel Corp., 12 pp, illus. Care and use of Type 430 MicroRold stainless steel sheet. Physical properties and analysis, relative corrosion resistance, fabrication and application. (119)

Stainless Steel Castings. Waukesha Foundry Co., 4 pp, illus., No. WF-5. Facilities for producing any hard-to-shape type of stainless steel castings. (120)

Metal Stamping. Worcester Pressed Steel Co., 8 pp, illus. Company facilities for custom metal stamping. (121)

Electric Weld Tube Mills. Yoder Co., 64 pp, illus. Reviews tube making processes and gives complete description of the cold forming, electric welding process—its development, its possibilities and its limitations. (122)

Mechanical Tubing. Youngstown Sheet & Tube Co., 4 pp, illus. Features size and wall thickness of a complete line of Yoloy electric weld mechanical tubing. (123)

Nonferrous Metals • Parts • Forms

Die Castings. Advance Tool & Die Casting Co., 8 pp, illus. Illustrates facilities for producing die casting to specifications. (129)

Aluminum Pipe. Aluminum Co. of America, 18 pp, illus. Aluminum pipe characteristics and advantages for each of its major fields of application. (130)

Aluminum Stainless Steel. Aluminum Goods Mfg. Co., Contract Div., 21 pp, illus. "Service to Industry" lists wide variety of component parts made for government and industry. Technical services and finishing and fabricating facilities are also described. (131)

Electrolytic Copper Powders. American Metal Co., Ltd., 3 pp. Data sheets give specifications for electrolytic copper powders. (132)

Bearing Bronze. American Smelting & Refining Co., Continuous-Cast Products Dept., 6 pp, illus., No. 301. Presents in tabular form all continuous-cast stock sizes and weights for solid and hollow bronze bars ½ to 9 in. in dia. (133)

Precision Castings. Atlantic Casting & Engineering Corp., 12 pp. illus. How to obtain nonferrous castings cast to ordinary machining tolerances. Describes process and gives alloy specifications. (134)

Magnesium, Aluminum Castings. Bendix Aviation, Eclipse-Pioneer Div. Foundries. "Book of Facts" shows company's facilities for custom making aluminum and magnesium castings. (135)

Machining Titanium. Cincinnati Milling Machine Co., 16 pp, illus.. No. M-1866. Discusses machining characteristics with emphasis on chip formation. (136)

Manufacturers' Literature

Aluminum Alloys. Peter A. Frasse & Co., Inc., 4 pp, illus. General properties, fabricating characteristics, typical applications and available size ranges of nine common aluminum alloys. (137)

Aluminum Alloy. Frontier Bronze Corp., 24 pp, illus. Describes Alloy 40-E, a high strength alloy containing zinc, magnesium, titanium and chromium. Alloy needs no heat treatment. (138)

Electroforming. Gar Precision Parts, Inc., 4 pp, illus. Process permits exact reproduction of intricate details on sheet or complex forms using permanent or expendable mandrels. (139)

Metal Powders. Glidden Co., 6 pp. Contains specification sheet for lead and Resistox copper powders. (140)

Zinc Die Castings. Gries Reproducer Corp., 8 pp, illus. Design information and physical data on zinc alloys for die casting. (141)

Aluminum Products. Harvey Aluminum, 8 pp, illus. Describes wrought aluminum products and gives engineering and design data. (142)

Die Castings. Hoover Co., 12 pp, illus., No. 853. Shows Hoover facilities for producing zinc and aluminum die castings. Includes design helps and describes applications. (143)

Laminated Metals. Improved Seamless Wire Co., Inc., 6 pp, illus. Describes applications of laminated metals in modern industry. (144)

Aluminum Extrusions. Kaiser Aluminum & Chemical Sales Corp., 24 pp, illus. Significance of two new 8000-ton extrusion presses. Includes extrusion design suggestions. (145)

Rare Earths. Lindsay Chemical Co., 12 pp, illus. Describes company's work in the rare earth field. (146)

Lithium Metals, Compounds. Lithium Corp. of America. Data sheets on properties and uses of lithium metal and organic and inorganic lithium compounds for metal treatment, ceramic modifications, welding, etc. (147)

New Titanium Alloy. Mallory-Sharon Titanium Corp., 4 pp. Properties of MST 6AL-4V, a highly stable titanium alloy for use at temperatures to 750 F. Includes heat treating data and stability test results. (148)

Titanium. Metal Hydrides, Inc., 2 pp, No. 600-C. Data sheet on titanium metal and facts on storage and handling. (149)

Extrusions and Castings. Curtiss-Wright Corp., Metals Processing Div., 16 pp, illus. Two bulletins describe method of extruding metals and the technique of casting top quality parts. (150)

Brass Powder Parts. New Jersey Zinc Co., 4 pp, illus. Describes applications of brass powder parts in self-developing cameras, rotors, drive bars. (151)

Precision Castings. Ohio Precision Castings, Inc., 12 pp, illus. Shows numerous examples of this company's brass, bronze, aluminum and beryllium copper plaster mold castings. (152)

Die Castings. Paramount Die Castings Co., 4 pp, illus. Describes facilities and services. Also shows representative aluminum, magnesium and zinc castings. (153)

Spun Shapes. Phoenix Products Co., Metal Spinning Div., 4 pp, illus. Describes Phoenixspun methods for spinning spherical and extra deep-drawn contours. (154)

Die Castings. Precision Castings Co., Inc., 24 pp, illus. Describes integrated facilities for quantity production of aluminum, magnesium and zinc die castings. (155)

Precision Metal Parts. REF Mfg. Corp., 10 pp, illus. Facilities for producing precision parts and assemblies for aircraft and electronic use. (156)

Titanium. Rem-Cru Titanium Inc., 12 pp. Data sheet on Rem-Cru C-130AM. (157)

Titanium and Its Alloys. Republic Steel Corp., 32 pp, illus., No. 588. A practical working manual presenting some basic data on commercial quality titanium and its alloys. (158)

Nonferrous Alloys. Riverside Metal Co. A reference and guide to specifying phosphor bronze, nickel silver, cupro nickel and beryllium copper. (159)

Zinc Die Castings. St. Joseph Lead Co., 25 pp, illus. Discusses role of zinc as a base metal for die casting alloys and lists the variety of commercial finishes for zinc base die castings. (160)

Centrifugal Castings. Sandusky Foundry & Machine Co., 6 pp, illus. Specification chart for ferrous and nonferrous alloys for centrifugal castings. (161)

Precision Investment Casting. Alexander Saunders & Co., 14 pp, illus. Discusses advantages of this process in comparison with conventional methods of production, techniques, equipment and supplies needed. (162)

Aluminum Strip. Scovill Mfg. Co., 20 pp, illus. Physical characteristics, temperature designations, weights and fabricating data for aluminum alloy strip. (163)

Small Wire. Secon Metals Corp., 2 pp. Research on and development and production of small precision wire. (164)

Bimetallic Construction. Arthur Tickle Engineering Works, 8 pp, illus. Describes Alumibond process for molecularly bonding aluminum and its alloys to iron and steel and their alloys. (165)

Light Metal Castings. Thompson Products, Inc., Light Metals Div., 8 pp. illus. Describes a complete line of precision die castings for various industrial uses. (166)

Brass Pressure Die Castings. Titan Metal Mfg. Co., 4 pp, illus. Outlines economical uses of brass pressure die castings as fabricated assembly parts. (167)

Screw Machine Products. Westfield Metal Products Co., 4 pp, illus. Describes facilities for production of a variety of machines, nuts and screw machine products. (168)

To obtain literature listed on these pages, use the convenient prepaid post card on pp 67 and 68.

Sintered Bearing Alloys. U. S. Graphite Co., Div. of Wickes Corp., 6 pp, illus., No. 18. Discusses design and metallurgical requirements for selection of sintered metal bearings. (169)

Thermometals and Special Alloys. H. A. Wilson Co., 2655 U.S. Route 22, Union, N. J., 192 pp, price $3.00. New Blue Book on thermostatic bimetals, sintered metals, electrical contact materials, composite and laminated metals and special alloys. Provides design data, graphs, formulas and properties and applications of hundreds of materials. Request from Wilson on company letterhead.

Spun Tubing. Wolverine Tube Div., Calumet & Hecla, Inc., 28 pp, illus. Advantages and numerous applications of the spun end process for nonferrous tube. (170)

Powder Metal Products. Yale & Towne Mfg. Co., Powdered Metal Products Div., 16 pp, illus. How Powdermet parts permit close tolerances, good wearability, controlled porosity and high ductility. Shows production facilities and typical products. (171)

Nonmetallic Materials • Parts • Forms

Polyester Resins. Barrett Div., Allied Chemical & Dye Corp., 14 pp. Technical data reports 55-1 through 55-12. Properties of rigid, flexible and resilient types of Plaskon polyester resins. (177)

Plastics Pipe, Fitings, Valves. American Hard Rubber Co., 6 pp, illus., No. 80-A. Noncorrodible plastics pipe with good impact strength and toughness. Physical properties, chemical resistance tables and installation and fabrication data. (178)

Corrosion Proof Cements. Atlas Mineral Products Co., 12 pp, No. 5-2. Latest data on five standard corrosion proof cements: furan, phenolic, sulfur, polyester and silica based materials. (179)

Prous Media. Carborundum Co., Refractories Div., 55 pp, illus. Data on Aloxite aluminum oxide porous media for various applications. (180)

Coated Fabrics. Connecticut Hard Rubber Co. Uses; chemical, electrical and mechanical properties; and availability of heat resistant, silicone rubber-coated glass fabrics. (182)

Extruded Plastics, Rubber. Conneaut Rubber & Plastics Co., 4 pp, illus., No. CR-53. Die making and production facilities for rubber and plastic extrusions. (183)

Honeycomb Material. Douglas Aircraft Co., Inc., Aircomb Section. Development of Aircomb, a honeycomb structure of Kraft paper impregnated with a phenolic resin. It is said to be 16 times as rigid as an equal weight of steel, fire resistant, pest resistant and an excellent insulator. (228)

Neoprene. E. I. du Pont de Nemours & Co., Inc., Elastomers Div., 8 pp, illus. Latest issue of "Neoprene Notebook" has article on the meaning of "heat resistance" in rubber and information on new neoprene applications. (184)

Teflon Coated Glass Fabrics. E. I. du Pont de Nemours & Co., Fabrics Div.,

4 pp. Electrical mechanical chemical, thermal and forming properties of Teflon-glass fabrics, as well as toxicity precautions and suggested uses. (185)

Plastics for Lighting. E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept., 11 pp, illus. Properties of Lucite acrylic resin and applications involving indoor and outdoor lighting. (186)

PVC Pipe. Easton Plastic Products Co., Inc., 9 pp. Three bulletins: chemical resistance of Easton polyvinyl chloride pipe; specifications on pipe and fittings; and instructions for threading, cutting and assembling PVC pipe and fittings. (187)

Felt. Felters Co., 22 pp. Design properties, selection and applications of felt and felt products. (188)

Irradiated Polyethylene Film. General Electric Co., Chemical & Metallurgical Div., 15 pp, illus. Technical report on Irrathene, an irradiated polyethylene film which does not melt at sterilizing temperatures. (189)

Polyethylene Tubing. Gering Products, Inc., 4 pp, illus. Describes Ger-Tube, a polyethylene tubing that is nontoxic and has good chemical resistance. (190)

Graphite. Graphite Specialties Corp., 4 pp, No. GS 101-1. An imperivous graphite, more than 99.5% pure carbon, for high temperature parts. Chemical resistance data and physical properties, including heat effects to 5700 F, are charted. (191)

Insulating Material. Hays Mfg. Co., 12 pp, illus., No. 100. Properties of Haysite, a glass-reinforced alkyd base polyester insulating material designed to meet rigid electrical standards. (192)

Plastics. Heil Process Equipment Corp., 4 pp, illus., Vol. 4, No. 1. Suggests applications for Rigidon, a glass-reinforced plastic; Rigidin, a rigid vinyl plastic; and Rigidene, a polyethylene plastic. (193)

Carbon and Rubber Products. Henrite Products Corp., 32 pp, illus. Gives information and data on typical company products in carbon and rubber fields. (194)

Balsa Wood. International Balsa Corp., 19 pp. Factual report on balsa wood, its growth, production, processing and uses. (195)

Fluorocarbon Rubber. M. W. Kellogg Co., 16 pp, illus. Data on Kel-F Elastomer, a fluororcarbon rubber that has thermal stability up to 400 F and resists acids, ozone and other oxidants. (196)

Adhesives. Koppers Co., Inc., Chemical Div., 8 pp, illus., No. C-6-230. Physical and chemical properties and various uses of resorcinol-formaldehyde compositions known as Penacolite Brittle Resins. (197)

Glass Fibers. L. O. F. Glass Fibers Co., 8 pp, illus., No. WPD-11. Shows application of glass fiber products in reinforced plastics and in yarns for the textile industry. (198)

Iron-Like Wood. Lignum-Vitae Products Corp., 16 pp. Mechanical and industrial applications of lignum-vitae, a hard tropical wood with a density almost equal to that of iron. It is noncontaminating, acid and chemical resistant, and self-lubricating. (199)

Glass and Ceramic Parts. Mansol Ceramics Co., 16 pp, illus. Glass preforms for hermetic seals, adhesives, steatite preform and multiform production facilities. (200)

Refractory Porcelain. McDanel Refractory Porcelain Co., 36 pp, illus. Catalog of high temperature porcelain products with physical, mechanical and electrical properties. (201)

Carbon Specialties. Morganite, Inc., 12 pp, illus. Design data reference for carbon specialties, including chemical and physical properties, and typical blank sizes and parts. (203)

Glass Bonded Mica. Mycalex Corp. of America, 24 pp, illus. Design information for parts to be machined from glass bonded mica. (204)

Boron Carbide. Norton Co., 16 pp, illus. A handbook on boron carbide, elemental boron, and other stable, boron-rich materials. (205)

Carbon Parts. Ohio Carbon Co., 4 pp, illus. Thermal, mechanical and electromechanical properties of company's carbon parts. (206)

Fiberglass. Pittsburgh Plate Glass Co., 4 pp, illus. Lists advantages of using glass fiber for sound and heat insulation applications. (207)

Carbon Graphite. Pure Carbon Co., Inc., 12 pp, illus., No. 55. Catalog on carbon graphite for mechanical applications. (208)

Plastics Sheets, Tubing. Pyramid Plastics, Inc. Price list and data on plastics tubing, pipe, rod, sheets and fittings. (209)

Packing. Quaker Rubber Corp., 6 pp, illus. Complete line of materials for hydraulic and other types of packing. (210)

Plastics Fabrication. Regal Plastic Co., 4 pp, illus. Custom contract service from designing and engineering to finished part, assembly or product—using plastics sheets, rods, tubes, reinforced fiberglass. Includes special bulletin on molded cases. (211)

Polyester Resins. Reichhold Chemicals, Inc. Brochure includes 11 technical bulletins describing Polylite line of liquid thermosetting polyester resins suitable for use in glass fiber reinforced applications. (212)

Plastics Hose. Resistoflex Corp., 4 pp. Flexible hose, assemblies and plastics products for heat and chemical resistant applications. (213)

Rubber. Roth Rubber Co., 1860 S. 54 Ave., Chicago, Ill. Actual rubber samples with hardness from 5 to 100 durometer. Accompanied by ASTM specifications and list of uses for each sample. Request Rubber Sampler No. MM3 from Roth on company letterhead.

Flexible Teflon Tubing. Sparta Mfg. Co., 4 pp. Properties and characteristics of Teflon thin-walled and spaghetti tubing. Suggested uses include: instrument tubing, electronic applications, wire sheathing, acid lines, steam or other high temperature lines. (214)

Ceramic Insulation. Star Porcelain Co., 3 pp. Specifications on center shoulder bushings, insulating washers and bushings made of steatite ceramic. (215)

Rubber Parts. Stillman Rubber Co., 24 pp, illus. Typical products and facilities for making custom molded rubber parts. (216)

Reinforced Plastics. Strick Plastics Corp., 4 pp, illus. Describes reinforced polyester laminate with good thermal, electrical, chemical and mechanical properties. Typical applications given. (217)

Polyurethane Foam. Surface Chemicals, Inc., 4 pp. Properties of Isothane foam for thermal insulation and sound control. (218)

Rubber Engineering Data. Tyer Rubber Co. Illustrates molded and extruded rubber products and provides technical specifications and relative properties, for natural rubber, Buna S, Buna N, neoprene, butyl, Thiokol and silicone. (219)

Tetrafluoroethylene. U. S. Gasket Co., No. 300. Tables and descriptive matter on chemical, electrical, thermal and mechanical properties of Teflon. (220)

Plastics Pipe. National Tube Div., U. S. Steel Corp., 28 pp, illus., No. 24. Data on unplasticized rigid polyvinyl chloride pipe, both normal and high impact types. Describes installation techniques. (221)

Metal-Plywood Laminate. U. S. Plywood Corp., 8 pp, illus. Gives special features, advantages and wide variety of uses for Armoply, sheet metal-bonded plywood. (222)

Vinyls and Polyesters. Naugatuck Chemical Div., U. S. Rubber Co., 8 pp, illus. Vinyl, polyester and elastomeric resins and compounds, applications, properties and processing. (223)

Felt. Western Felt Works, 28 pp. Discussion of felt, its applications, composition, specifications and testing methods. (224)

Extruded Plastics. Western Textile Products Co., Extruded Plastics Div., 4 pp, illus. Describes company experience in extrusion and shows special problems solved. (225)

Acrylic Rod, Tubing. Westlake Plastics Co., 3 pp. Prices and specifications on methacrylate rod and tubing made by Lubo-Film extrusion and Liquo-Temp annealing processes. (226)

Finishes • Cleaning & Finishing

Barrel Finishing. Abbott Ball Co., 8 pp, illus. Describes barrel finishing techniques with a new design tumbling barrel. (233)

Lubricating Coatings. Alpha Molykote Corp., 4 pp, illus. New technical house organ, "Lubrication Newsletter," discusses press fittings with molybdenum disulfide lubrication. (234)

Hot Dip Galvanized Coatings. American Hot Dip Galvanizer's Assn., Inc., 16 pp, illus. Description of hot dip galvanizing process in industrial and consumer applications. (235)

Plastics Finish. John L. Armitage & Co., 8 pp. Information on Armorhide, a textured plastics finish resembling leather. (236)

Manufacturers' Literature

Protective Coatings. Ceilcote Co., 8 pp, illus., No. C-150. Gives base formulations, chemical properties and adhesion characteristics of seven standard organic coatings. Includes simplified chart for selecting coatings surface treatment, processes, etc. (238)

Metallic Coatings for Plastics. Coating Products. Attractive brochure describes the various coatings applied to plastics materials. Samples included. (239)

Brush Plating. Dalic Metachemical Ltd., 4 pp, illus. Presents advantages of brush plating with the Dalic process. (240)

Black Oxide Finish. Du-Lite Chemical Corp. Information on finishes for steel blackening. Also information on Du-Lite cleaner, strippers and burnishing compounds. (241)

Abrasives. Elgin National Watch Co., 4 pp, illus. Describes Dymo-C, a diamond abrasive for finishing carbide dies. (242)

Solution Coating Resin. Firestone Plastics Co., 8 pp, No. 13. Properties and uses of Exon 450 vinyl chloride copolymer resin for solution coatings, either permanent or strippable. (243)

Resin Coatings. General Mills, Inc., Chemical Div., 8 pp, No. 11-4-3. Data on polyamide resin-epoxy thermoset composition and their use as paper coating and laminating materials. (244)

Corrosion Prevention. Metallizing Engineering Co., Inc., 4 pp, illus. Description of Metco Systems and how these pure metallized zinc or aluminum coatings prevent corrosion. Typical applications shown. (246)

Colored Silicone Finishes. Midland Industrial Finishes Co., illus. An interesting discussion of the application of colored silicone finishes. (247)

Paint Stripping. Oakite Products, Inc., 14 pp, illus. Procedures followed in four different stripping methods: steam gun, hot flow-on, cold spray and tank. Also how to protect stripped parts in storage and how to perpare them for repainting. (248)

Blast Cleaning, Dust Control. Pangborn Corp., 16 pp, illus., No. 226. Describes various models of "Continuous-Flo Rotoblast" barrels available for production line blast cleaning to reduce cleaning costs. (250)

Precoated Strip. Thomas Strip Div., Pittsburgh Steel Co., 18 pp, illus. Strip steel electrolytically and hot dip coated with zinc, copper, brass, lead alloy, nickel or chromium with or without rolled-in patterns. Includes 10 sample disks of coated strip. (252)

Metal Finishing. Promat Div., Poor & Co., 4 pp, illus. Explains Pre-Galv process of controlling galvanizing operations by use of only one addition to each of the pickle and flux operations. (253)

Electrostatic Painting. Ransburg Electro-Coating Corp., 16 pp, illus. Explains electostatic spray painting and shows the process used in the finishing of automobile chassis, refrigerator cabinets, door knobs, toys and other products. (254)

Crack-Free Chromium. United Chromium Div., Metal & Thermit Corp., 4 pp, illus., No. CFC-1. Outlines properties of finishes obtainable with the new Unichrome, crack-free chromium plating process. (255)

Porous Chromium Coatings. Van der Horst Corp. of America, 12 pp, illus. Describes oil retaining, wear resistant chromium coating for bearing surfaces, cylinder walls and other applications where hard wear and lubrication are factors. (256)

Methods & Equipment

Hardness Testers. Riehle Testing Machines, Div. of American Machine & Metals, Inc., 4 pp, illus., No. RH-1154. Portable hardness testers for Rockwell readings with scales A, B, C, D, F and G. (262)

Silver Brazing. American Platinum Works, 16 pp. Manual on selective fluxing for low temperature silver brazing. (263)

Stainless Fasteners. American Screw Co., 7 pp. Gives physical properties and applications. Describes cold heading and other fabricating techniques. (264)

Industrial Radiography. Atomic Energy of Canada, Ltd., Commercial Products Div. Up-to-date information on nondestructive testing of metals by gamma radiography. (265)

Spectrograph. Bausch & Lomb Optical Co., 14 pp. Describes a 1.5-meter stigmatic spectrograph for laboratory use. (266)

Black Light. Black Light Corp. of America, 65 pp, illus. Long wave ultraviolet light for industrial inspection and flaw detection. Case histories plus data on research in this field. (267)

Chrome-Moly Electrode. Champion Rivet Co., 13 pp, No. CM-55. Low hydrogen welding electrodes for chromium molybdenum alloy steels. Data include physical and mechanical properties of welds, chemical analysis of weld deposit and a discussion of welding procedure. (268)

Projection Gaging. Eastman Kodak Co., 12 pp, illus. Describes four models of the contour projector and their accessories for use in inspection. (270)

Decimal Equivalent Chart. John Hassall, Inc. Easy-to-read decimal-equivalent wall chart of this company's cold headed parts. (273)

Heat Treating Furnaces. Hevi Duty Electric Co., 8 pp, illus., No. 653. Describes furnaces for annealing, stress relieving, nitriding, etc. (274)

Pyrometers. Illinois Testing Labs, Inc., 6 pp, illus. Thermoelectric pyrometer for precision measurements of temperatures beyond 1000 F. (276)

Hardness Conversion Tables. International Nickel Co., Inc. Celluloid card, 2¾ x 4¾ in., gives approximate relationship between Brinell, DPH (Vickers), Rockwell and Shore Scleroscope hardness values and corresponding tensile strengths of steels. (277)

Atmosphere Control. Leeds & Northrup Co., 20 pp, illus., No. TD4-620(1). How to control surface carbon content automatically in heat treating steel. (278)

Electrodes, Holders. P. R. Mallory & Co., Inc., Welding Div., 2 pp, illus., No. 8-11. Advantages, design and application of 8-deg ⅝-dia spot welding electrodes and holders. (279)

Rivets. Milford Rivet & Machine Co. A handy slide rule selector gives complete rivet specifications. (280)

Tubular Furnaces. Marshall Products Co. 4 pp, illus. Discusses both the creep test and tensile test models of Marshall tubular furnaces, as well as control panels and radial brackets. Includes specifictions. (281)

Furnace and Oven Controls. Minneapolis-Honeywell Regulator Co., 44 pp, illus., No. 54-1. Catalog and price list on Brown instruments and Honeywell controls for industrial furnace and oven equipment. (282)

Induction Brazing. Ohio Crankshaft Co. "Typical Results of Tocco Induction Brazing and Soldering" shows by case histories the advantages of these joining methods. (284)

Pyrometers. Pyrometer Instrument Co., Inc., 8 pp, illus., No. 175. Catalog of optical micro-optical, radiation, immersion, surface and indicating pyrometers for precision temperature measurements. (285)

Cold Cabinet. Revco, Inc., 2 pp. Low temperature cabinet for industrial processes and research. (286)

Screws. Russell, Burdsall & Ward Bolt & Nut Co., 8 pp, illus. Advantages and specifications of Spin-Lock screws available in hex, pan, truss or flat heads. (287)

Set Screws. Set Screw & Mfg. Co., 24 pp, No. 19. Lists prices and dimensional information. (288)

Ultrasonic Inspection. Sperry Products, Inc., 8 pp, illus., No. 50-105. Explains principle of ultrasonic inspection and illustrates latest types of equipment. (289)

Heat Treating Equipment. Stanwood Corp., 4 pp. Brief description of types of heat treating equipment with suggested applications. (290)

Metal Powder Press. F. J. Stokes Machine Co., 4 pp, illus. Information on a 50-ton multiple-motion powder metal press. (291)

Brazing Alloys. United Wire & Supply Co., 3 pp, illus. Wire brazing aluminum for low temperature brazing of various metals and alloys. (293)

Inert Gas Welding Process. Westinghouse Electric Corp., Welding Div., 7 pp, No. B-6525. Performance and applications of consumable electrode inert gas welding process. (294)

Electric Radiant Panels. Edwin L. Wiegand Co., 4 pp, illus., No. L-1093. Detailed specifications of Chromalox electric far-infrared radiant panels for heavy duty industrial heating, drying and curing operations. (296)

To obtain literature listed on these pages, use the convenient prepaid post card on pp 67 and 68.

One Point of View:

Let's teach engineers how to think

Everyone seems to have an opinion these days about what should be done to improve engineering education. Many say that teaching of the fundamentals—mathematics and the sciences—is being neglected. An equal number argue that there should be less emphasis on fundamentals and more attention paid to practical engineering courses. Others believe there should be more specialized curricula, and still others say there should be fewer.

Although these suggestions for improving the engineer's education probably warrant careful thought, we believe a more fundamental need in technical education has been overlooked too frequently. It is the need to teach engineers how to think.

Few are trained

It has long been recognized that the most important elements contributing to the solution of most engineering or technical problems are the generation of ideas and the use of the analytical or scientific method. Yet it is a sad fact that very few engineers have ever had any formal or explicit training in the methods of science or in the techniques of problem solving or in so-called "creative thinking." The result is that although the engineer acquires a wealth of factual knowledge, both fundamental and practical, he seldom learns how to use it most effectively.

Tests prove need

The importance of analytical thinking in engineering work was demonstrated by the results of tests reported in a recent article appearing in *The Engineer* (London). The author, P. P. Love, tested the thinking ability of a number of engineers by measuring the time required for them to solve typical technical problems. The results definitely showed that those using an "unconventional" analytical approach developed solutions in less time and at less cost than those not trained in the techniques of effective thinking. In one case the difference in time was as great as four to one.

It is encouraging to note that a number of our large manufacturing companies and some branches of the Federal Government have recognized the value of "creative thinking" and are giving their technical personnel, as well as others, training in the art of thinking. Some of the techniques they teach have been known and used successfully for many years. Others, such as the technique of "brainstorming," are relatively new.

Schools must do it

But training of engineers in the techniques of thinking and problem solving should not be left to industry. It is the job of our engineering schools. In the past, many educators have assumed that students intuitively acquire correct thinking habits during the course of their engineering and scientific studies. But studies such as the one cited above indicate that this is not the case. Students must be given explicit instruction in the scientific method and in the techniques of thinking and problem solving. Through such training, engineers will be prepared to solve more efficiently the complex technological problems of the future.

Many different uses, many different materials—*Among the myriad of uses for polyethylene are squeezable bottles, nonwetting bottle caps, flexible ice trays and noncorrodible flashlight cases.*

If you plan to use polyethylene, you should get acquainted with three important terms: melt index, density and molecular weight distribution. By showing how these parameters are related to engineering properties, this article tells you . . .

How to Pick the Right Polyethylene

by E. T. Darden and C. F. Hammer,
Polychemicals Dept., E. I. du Pont de Nemours & Co., Inc.

■ Available physical and mechanical property data are frequently inadequate for predicting the performance of a given type of polyethylene in a specific use. With a more basic understanding of the molecular parameters, which determine the properties of the material, the designer or engineer has a better basis for selecting a resin to meet any particular combination of requirements. Though the effects of melt index and density on end-use properties have long been appreciated, another variable—molecular weight distribution—has recently been found to have important effects.

Definitions of the important molecular parameters are given in the accompanying box. In brief, *melt index (MI)* is a measure of the fluidity of the molten material for certain specified conditions. *Density* is a measure of the degree of crystallinity of the material. *Molecular weight distribution (MWD)* is a measure of the amount of *scatter* or nonuniformity of molecular sizes within the material.

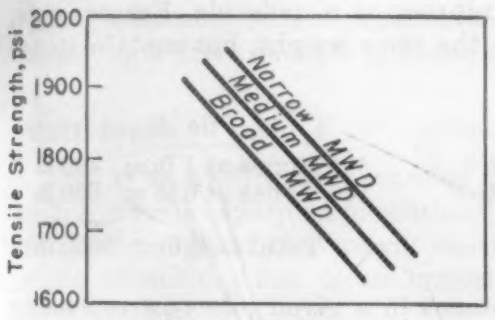
The fundamental molecular parameters, their interrelationships, and their effects on resin properties form an extremely complex subject. The molecular size, number of side chains and length of the side chains are independently variable. Because polyethy-

lene is always a mixture, they must be dealt with statistically.

Fortunately, the picture can be greatly simplified by the use of the three composite or secondary parameters mentioned above. In terms of end-use properties, polyethylene resins can be fairly well classified on the basis of melt index, density and molecular weight distribution. The accompanying box shows how each of these three variables affects the properties of the product. By selecting a resin having the optimum values of these three variables, the desired combination of properties can usually be obtained.

Mechanical properties

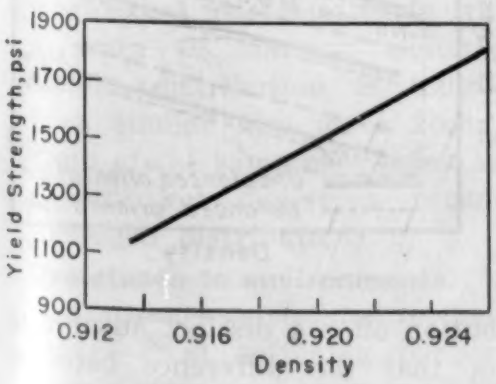
Tensile strength—Ultimate tensile strength of polyethylene depends on melt index and molecular weight distribution. The lower



the melt index and the narrower the molecular weight distribution, the higher the ultimate tensile strength. Minor changes in density have little, if any, effect.

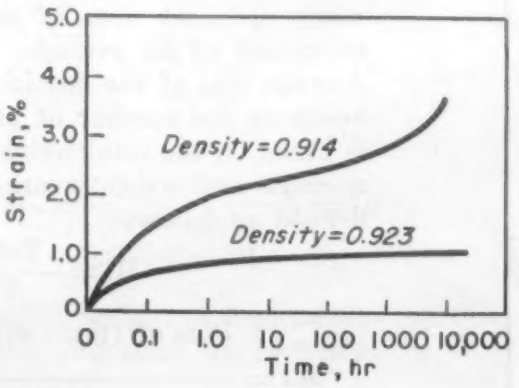
Test method used is ASTM D638-52T, modified by straining at 20 in. per min instead of the 0.2 in. per min specified. For thin test specimens, the numerical results are virtually the same at the two speeds.

Yield strength—Yield strength of sheets or bars molded of polyethylene is dependent only on the



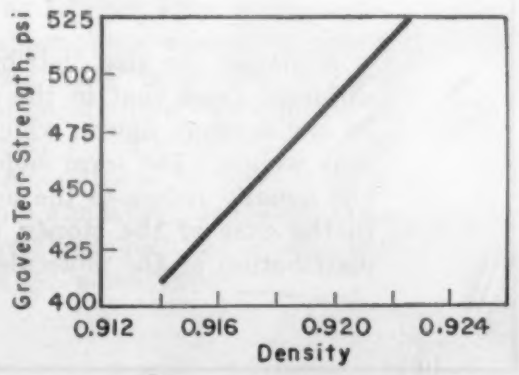
crystallinity (as measured by the density of the sample). Melt index and molecular weight distribution have little or no effect.

Creep—The slow yielding of objects subjected to stresses below the yield point for extended periods of time is called *creep*. This is, in varying degrees, character-



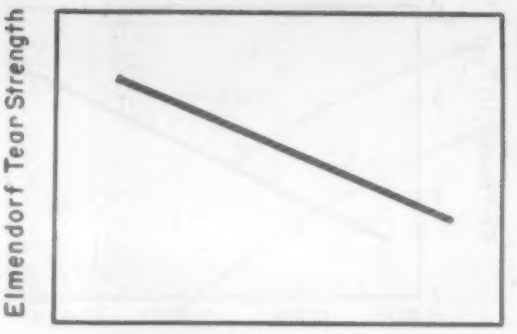
istic of all thermoplastic materials. In the case of polyethylene, the rate of dimensional change at a given stress and temperature depends primarily on the crystallinity (density) of the resin. The higher the density, the less will be the creep.

Tear strength—The tear strength of polyethylene film as measured by the Graves Tear Test (ASTM D1004-49T) is dependent on the density of the sample.



There is only a small dependence on melt index, and no dependence on number-average molecular weight or molecular weight distribution.

The Elmendorf Tear Test (ASTM D689-44), or pendulum impulse test, is a measure of resistance to propagation of a tear at high speed. It is dependent on the toughness of the resin. In polyethylene resins that are otherwise similar, the Elmendorf value



decreases with increasing melt index. Other structural characteristics have considerable effect on Elmendorf tear strength. However, the interactions of these variables are not well understood at this time.

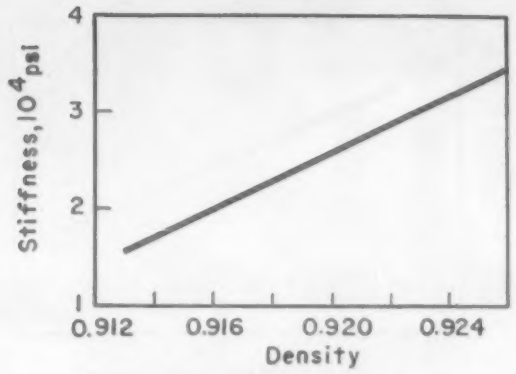
Stiffness—The stiffness of polyethylene is extremely sensitive to changes in the crystallinity. A small error in the measurement of density can account for a wide deviation from the expected stiffness-density relationship. Thus,

Effects of Variables on End-Use Properties

Increase in density:
- Stiffness increases
- Yield strength increases
- Tear strength increases
- Resistance to creep increases
- Vicat softening temperature increases
- Resistance to permeation by liquids and gases increases
- Low temperature brittleness decreases
- Brittleness increases
- Flex life decreases

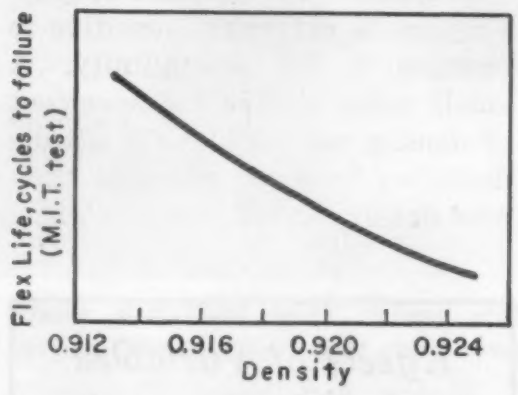
Increase in melt index:
- Melt fluidity increases
- Melt "drawability" increases
- Film coefficient of friction increases
- Tensile strength decreases
- Resistance to environmental stress cracking decreases
- Resistance to creep decreases

Narrowing of molecular weight distribution:
- Tensile strength increases
- Film brittleness decreases
- Low temperature toughness increases
- Vicat softening temperature increases
- Resistance to environmental stress cracking increases
- Fabricability at high shear stresses decreases



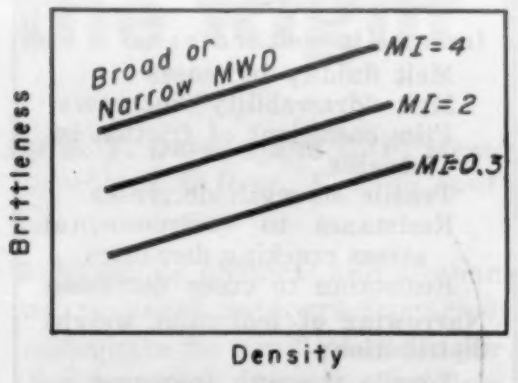
it is not known whether the apparent deviations sometimes encountered are real or not. As yet, no relation has been observed between such deviations and any molecular characteristic.

Flex life—The flex life of polyethylene (by MIT test) has a



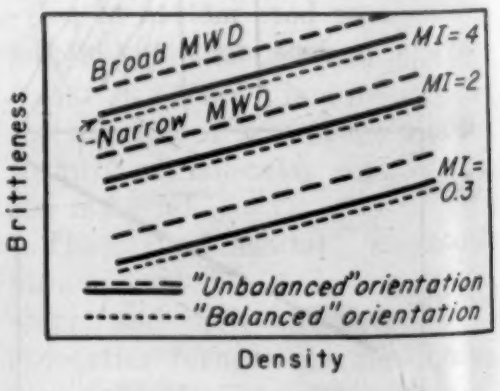
fairly strong dependence on short-chain branching, as reflected in annealed density. In otherwise similar resins, flex life is improved by decreasing melt index and by narrowing molecular weight distribution.

Film brittleness — The term *brittleness* as applied to polyethylene film usually means the tend-



ency of a creased film to split smoothly along the crease when it is stressed rapidly. The effects of density and melt index on the brittleness of "balanced" film are shown qualitatively in the curves. Balanced film is blown film oriented equally in both directions. This is a desirable state, but one that is difficult to attain.

All flat polyethylene film, and most blown film, is oriented more in the machine direction than in the transverse or circumferential direction. As the orientation becomes more unbalanced, the film becomes more brittle when stressed in the direction perpendicular to the direction of orientation. However, resins with a narrow molecular weight distri-



bution offer a distinct advantage in that the difference between

What the Terms Mean

Molecular Weight Distribution

The molecular weight of a pure substance may be defined as the weight in grams of 6.022×10^{23} molecules. This number of molecules constitutes a gram-mole, usually referred to simply as a mole. When dealing with a material like polyethylene, which contains many different sizes of molecules, the molecular weight must be expressed as an average. There are two ways of calculating the average size of the particles in a mixture. The *number-average* is based on the number of particles present, and the *weight-average* is based on the total weight of the particles of each size. Number-average and weight-average molecular weights, M_n and M_w, are defined as follows:

$$M_n = \frac{\text{Total weight of all molecules}}{\text{Total number of molecules}}$$

$$M_w = \frac{\text{Sum of (total weights of molecules of each size x their respective weights)}}{\text{Total weight of all molecules}}$$

The significance of these definitions can be shown by an analogy in which piles of stones are compared with samples of polyethylene and each stone within a pile represents a molecule. For example, two piles of stones might have the same weight, but contain stones of different sizes, like this:

Pile A		Pile B	
500 stones at 1 lb =	500 lb	400 stones at 1 lb =	400 lb
2 stones at 250 lb =	500 lb	100 stones at 6 lb =	600 lb
Total weight =	1000 lb	Total weight =	1000 lb

The average weight of the stones in a given pile (corresponding to the number-average molecular weight, M_n) is the total weight divided by the number of stones:

$$M_n = \frac{1000 \text{ lb}}{502 \text{ stones}} = 1.99 \qquad M_n = \frac{1000 \text{ lb}}{500 \text{ stones}} = 2.0$$

Although the size distribution of the stones in one pile is vastly different from that in the other, this important fact is not shown by the average figure, which corresponds to number-average molecular weight. The term *molecular weight* when applied to polyethylene usually refers to the number-average molecular weight and, as in the case of the stones, does not provide a measure of the size distribution of the molecules within the sample.

Returning to the stone analogy, the equivalent of weight-average molecular weights would be calculated as follows:

		Pile A				Pile B	
500 total wt of 1-lb stones	x	1 wt of individual stone	= 500	400 total wt of 1-lb stones	x	1 wt of individual stone	= 400
500 total wt of 250-lb stones	x	250 wt of individual stone	= 125,000	600 total wt of 6-lb stones	x	6 wt of individual stone	= 3600
			125,500				4000

$$M_w = \frac{125{,}500}{1000 \text{ (total wt of all stones)}} = 125.5 \qquad M_w = \frac{4000}{1000 \text{ (total wt of all stones)}} = 4.0$$

The ratio of the weight-average molecular weight to the number-average molecular weight gives a good indication of molecular weight distribution:

$$\frac{M_w}{M_n} = \frac{125.5}{1.99} = 63 \text{ (broad)} \qquad \frac{M_w}{M_n} = \frac{4.0}{2.0} = 2 \text{ (narrow)}$$

The molecular weight distribution value for Du Pont polyethylenes ranges from about 5 to about 40.

Melt Index

This is an arbitrary measure of the fluidity of the molten polymer under certain specified conditions (ASTM D1238-52T). It is a function of both the weight-average molecular weight and the chain branching, and is an important, but not exact, measure of fabricability.

Density

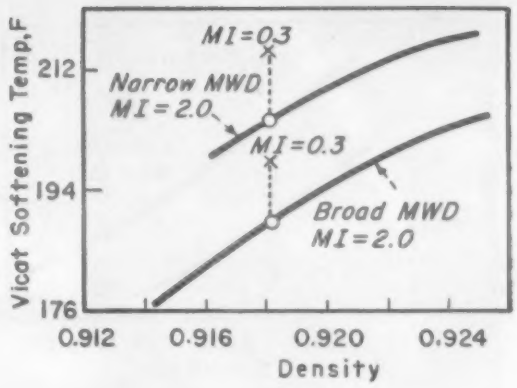
This is a measure of the crystallinity of polyethylene. The maximum density or crystallinity that can be reached by a given material is a decreasing function of the short-chain branching index. In actual practice, the ultimate crystallinity is seldom if ever reached, but increases with time almost indefinitely. Two resins of identical short chain branching index may reach different levels of crystallinity during identical fabrication conditions because of other structural differences. However, a simple annealing treatment (1 hr at a temperature just below the crystalline melting point) will generally bring the density of each to the same value.

balanced and unbalanced film is less noticeable. In effect, this means that most film made from a resin of narrow molecular weight distribution is tougher than similar film made from a resin of the same melt index and density but having a broader molecular distribution.

Resistance to environments

Resistance to elevated temperatures—Vicat softening temperature is often used as an indication of the ability of the resin to withstand stresses at elevated temperatures. In measuring Vicat softening temperature, the specimen is penetrated by a rod of standard size and weight, as the specimen is heated at a constant rate. The temperature at which the rate of penetration reaches a specified value is the Vicat softening temperature.

The factors controlling Vicat softening temperature are similar



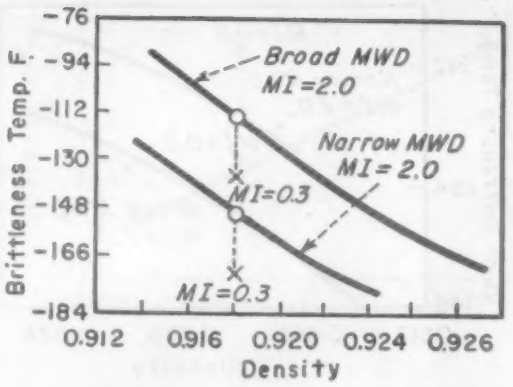
to those for low temperature brittleness.

The effects of density, melt index and molecular weight distribution are shown by the accompanying curves.

The lower line represents polyethylene resins of broad molecular weight distribution and melt index of about 2.0. The upper line represents the resins of narrow molecular weight distribution and melt index of 2.0. The points marked with X's show the effect of reducing the melt index to about 0.3 at a given density and molecular weight distribution. The highest Vicat softening temperature would be found in a resin having the highest density possible, the lowest melt index and the narrowest molecular weight distribution.

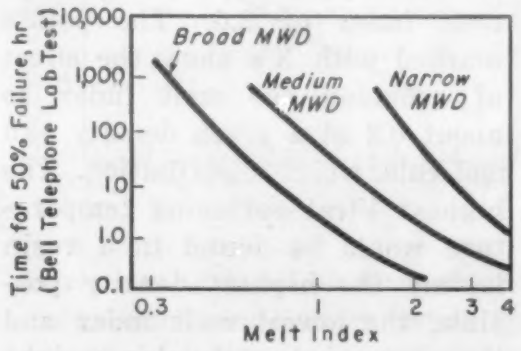
Resistance to low temperature — Low temperature brittleness (ASTM D746-52T) is affected by density, melt index and molecular weight distribution. The relationships are indicated by the curves.

The upper and lower lines each represent a series of resins of equal melt index (about 2.0), covering a range of densities. The upper line represents resins having a broad molecular weight distribution and the lower line indicates those of narrow molecular weight distribution. The points marked with X's indicate the effect of lowering the melt index to about 0.3 with each type of distribution. Because the breadth of the molecular weight distribution is not specified, values taken from the curves are only approximate. The point illustrated is that the utmost in low temperature toughness would be found in a very dense polyethylene resin of ex-



tremely low melt index and the narrowest possible molecular weight distribution.

Environmental stress-cracking—The test for environmental stress-cracking measures the tendency of the resin to crack when stressed in the presence of certain activating agents. It is an accelerated test employing an elevated temperature and a high con-



centration of active cracking agent. The resistance of polyethylene to environmental stress-cracking is extremely dependent on melt index. It is also dependent on molecular weight distribution to a great extent. High density increases tendency to stress-cracking, but this effect is relatively small in resins of low melt index.

Other properties

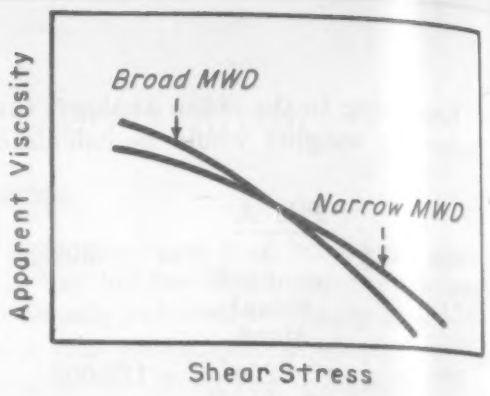
Permeability—The permeability of polyethylene to liquids and gases is dependent on the density or crystallinity of the specimen. The higher the density of the piece, the lower will be the permeability. Melt index and molecular weight distribution apparently have little or no effect.

Film shrinkage—Shrinking of polyethylene film is of commercial importance in the field of packaging. Shrinkage baths are maintained at a temperature of about 220 F and shrinkage should take place in about 3 sec. The amount of shrinkage that will occur depends on the amount of orientation or cold drawing the film receives during manufacture and the degree of long chain branching of the polymer. The temperature at which shrinkage will take place at a suitably rapid rate depends on the crystalline melting point of the resin. This, in turn, depends on the annealed density of the resin. The lower the density, the lower will be the temperature at which rapid shrinkage will occur.

Processing characteristics—Melt index is a convenient value often used as a measure of the processibility of a polyethylene resin. Much misunderstanding is caused by the expectation of a precise and unvarying relationship. By its definition, melt index is a measure of melt flow at one particular set of conditions. It is an excellent measure of processing characteristics *at these conditions* of temperature and shear stress. When different conditions of processing are employed, the molecular weight distribution must be considered.

In a Newtonian fluid, such as water, any applied shear stress causes shear flow directly proportional to the stress applied. If the force on the fluid is doubled, the flow will be exactly doubled. In other words, the viscosity remains the same at all shear stresses. Polyethylene melts, on the other hand, are non-Newtonian fluids, and their viscosities decrease as the applied stresses are raised. Furthermore, the amount of deviation from Newtonian behavior depends on the molecular weight distribution (M_w/M_n) of the particular polyethylene.

The curves show the effect of molecular weight distribution on melt behavior of two polyethylenes of identical melt index. The curves cross at the shear stress corresponding to that employed in determining melt index. At lower shear stresses, the resin with the narrower molecular weight distribution is the less viscous. At higher shear stresses (those usually employed in commercial proc-



esses), the resin with the narrower distribution is the *more* viscous.

It must be recognized that this difference is important only when melt viscosity is a limiting factor during processing. In many cases, such factors as melt fracture, solidification rate, etc. are controlling. It should not be concluded, even when melt viscosity *is* the limiting factor, that resins of broad molecular weight distribution are necessarily preferable. Narrow distribution often contributes important advantages. Frequently a better combination of physical properties and processibility is obtained by selecting a material of narrower molecular weight distribution and higher melt index.

Because of the complicating effect of molecular weight distribution, melt index has been condemned in some quarters as an unreliable test. Actually, when properly used, melt index is not only a convenient measure of processibility, but it is an important measure of the combined effects of weight-average molecular weight and chain branching.

Acknowledgement

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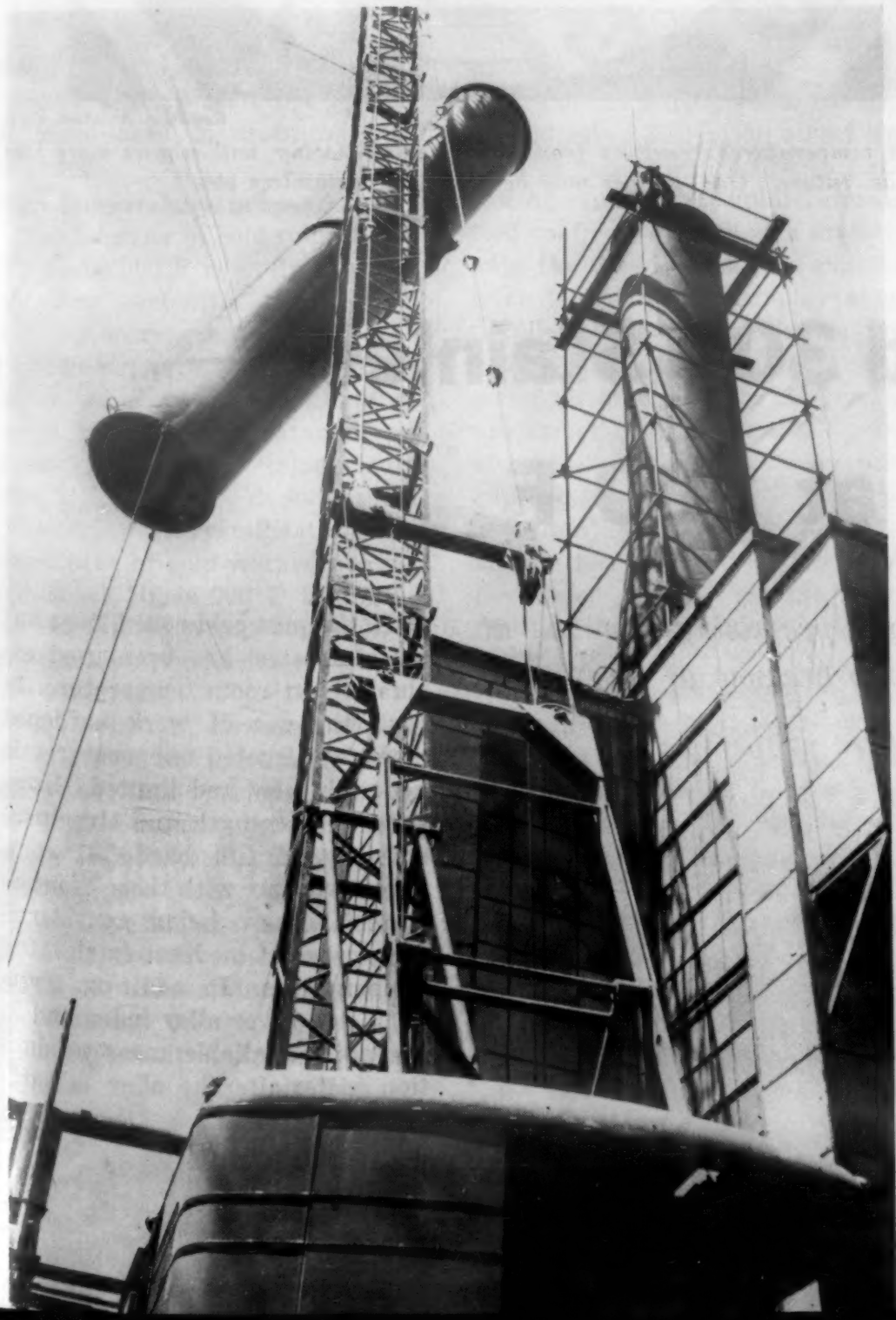
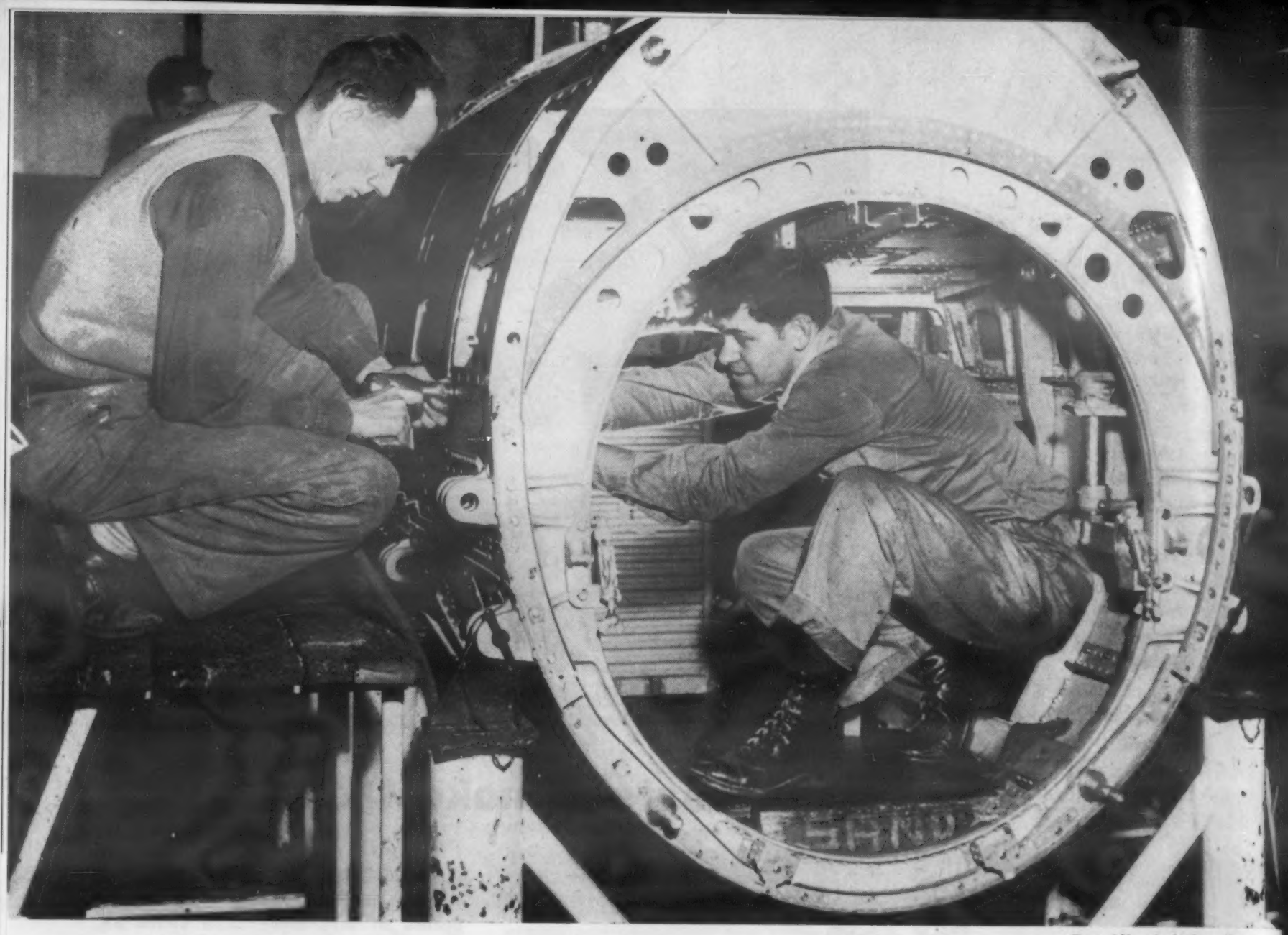
Thickness *of the striated dark blue coating being checked by the inspector is 0.10 +0.002 in. The acid resistant glass is fused to ¼-in. steel at 1600 F. Operating temperatures range from 750 F for continuous duty to 850 F for intermittent duty. Each stack section is flanged at the ends for field assembly by bolting.*

Glass-coated smokestack



The glass-coated smokestack being installed here costs about 50% more than an unlined stack, but it is expected to last more than twice as long. Made by A. O. Smith Corp., the stack has glass coatings on both interior and exterior. They are expected to eliminate accelerated corrosion normally encountered at low flue gas temperatures. The coatings, inside and out, weigh 5 oz per sq ft compared with conventional linings, inside only, that weigh up to 50 lb per sq ft. Hence, taller stacks are feasible, an advantage that may be important to users faced with air pollution problems. A damaged area of the stack can be repaired by flame cutting and bolting on a coated patch. High temperature plastics coatings protect exposed bolt threads from atmosphere corrosion.

MATERIALS AT WORK



Republic Aviation Corp.

Airframes, *increasingly subject to high temperatures resulting from aerodynamic heating, will require more heat resistant materials than aluminum in the future. One answer may be a full hard stainless steel.*

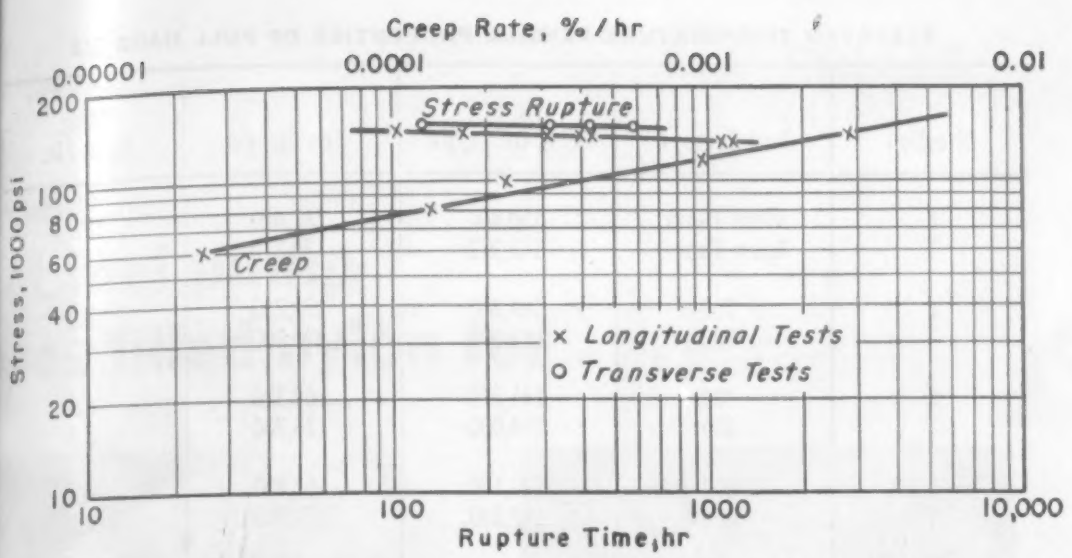
Cold Worked 301 Stainless— Still Strong at 800 F

This work hardening steel looks promising for use at moderately elevated temperatures because of its:

- *Excellent creep and rupture properties*
- *Good structural stability*
- *Low alloy index*
- *Ready availability*

by R. A. Lula, *Associate Director of Research, Stainless Steel, Allegheny Ludlum Steel Corp.*

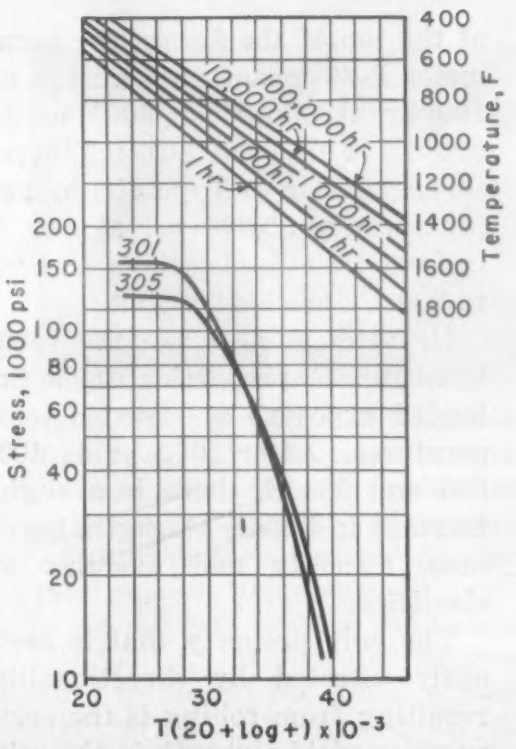
■ In the past cold rolled Type 301 stainless steel has been used exclusively at room temperature. In fact, the use of work hardened steels at elevated temperatures is generally new and limited. However, the strength and structural stability of full hard 301 compare favorably with those of other materials now being considered for service at moderately elevated temperatures. In addition, Type 301 has a lower alloy index and is a readily available mass production material. The alloy is suit-



***Stress rupture** and creep strength of full hard 301 at 800 F.*

EFFECT OF STRESS RELIEVING AT 800 AND 900 F ON YIELD STRENGTH IN COMPRESSION OF FULL HARD 301

Condition	Rockwell Hardness	0.2% Offset Comp Yld Str, psi	Mod of Elast (Comp), psi
Full Hard 301	Rc 42	110,000	22.2 X 10^6
Stress relieved 2 hr at 800 F	Rc 42.5	147,500	26.9 X 10^6
Stress relieved 2 hr at 900 F	Rc 42.5	147,200	26.1 X 10^6
Stress relieved 12 hr at 900 F	Rc 44	155,800	27.0 X 10^6



***Master rupture curves** for 40% cold rolled Types 301 and 305. These curves are developed by the Miller and Larson parameter plot which yields a single curve regardless of test temperature. In the parameter, T is absolute temperature in degrees Rankin and t is rupture time in hr.*

able for parts subjected to aerodynamic heating up to 800 F such as those used in airframe construction.

High temperature properties

The behavior of cold rolled Type 301 above 900 F is similar to that of other austenitic steels. Cold working increases the creep and rupture strength, but recrystallization, which occurs eventually at these higher temperatures, reduces the high temperature strength severely. Even without considering recrystallization, the usefulness of cold worked austenitic steels above 900 F is limited because other materials such as the precipitation hardening grades are stronger.

Below 900 F, however, recrystallization is not a factor even for extended time periods and the strength developed by work hardening compares favorably with that of more highly alloyed materials. Type 301 has the additional advantage over other austenitic steels of maintaining up to approximately 900 F the higher strength resulting from the martensitic transformation that occurs during cold rolling.

One of the objections to the use of cold rolled 301 is the directionality in mechanical properties resulting from the unidirectional cold rolling operation. To investigate the effect, tensile properties were determined on samples taken parallel and perpendicular to the rolling direction. Direction has no important effect on the tensile properties as can be noted in the accompanying table. Creep and rupture strengths of full hard 301 are shown in a graph. In addition to showing excellent properties under long time loading, these results confirm the structural stability of the material.

To determine the variation in properties between a stable (Type 305) and a metastable steel (Type 301), the stresses for rupture were determined for both grades on 40% cold rolled sheet at various temperatures. A 40% reduction was selected because it corresponds with full hard temper for Type 301. Results are shown in a Miller and Larsen parameter plot. The curve for 301 is higher than the 305 curve up to a parameter P-32. The difference is substantial, however, only up to P-30. Converted in time and temperature with the aid of the curves

Why Hard 301 Is Widely Used

Type 301 with a nominal composition of 17 chromium, 7% nickel, is the most metastable grade of the austenitic steels. Consequently, part of the austenite transforms to martensite during cold rolling. The hardening effect of this transformation adds strength to the inherently high work hardening characteristics of the remaining austenite. As a result of this double mechanism, Type 301 develops the highest strength of all austenitic steels.

A favorable combination of strength and ductility is responsible for the widespread applicaiton of ¼, ½ and full hard Type 301 in stationary and particularly in mobile structures requiring a high strength-weight ratio and good corrosion resistance.

at the top of the figure, the parameter P-30 means rupture life of 100 hr at 900 F or 6000 hr at 800 F. Full hard 301 is, therefore, superior to Type 305 by approximately 35,000 psi at 800 F in long time applications and up to 900 F for shorter times.

Of interest also are the room temperature properties after extended exposure at elevated temperatures. After 1000 hr at 400, 600 and 800 F, there is a slight increase in tensile strength, hardness, ductility and modulus of elasticity.

The only property that is seriously affected by directionality resulting from rolling is the compressive yield strength in the rolling direction. A corrective stress relieving treatment at 800 or 900 F can eliminate directionality and restore the compressive yield strength. Stress relieving also increases the modulus of elasticity.

Comparison with other materials

Full hard 301 is compared with several other alloys currently under investigation for aircraft construction in an accompanying graph. Based on tensile strength, 301 compares favorably with Inconel X, AM-350, 17-7 PH and A-286, all of which are more highly alloyed materials. Based on creep and rupture strength, 301 compares favorably with AM-350 and 17-7 PH at 800 F also. Data were not available for the other alloys at this temperature.

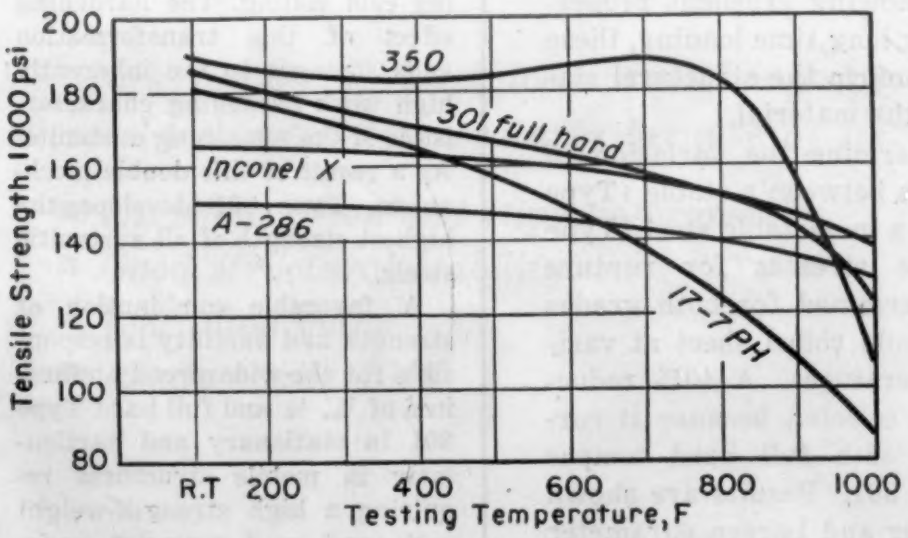
ELEVATED TEMPERATURE TENSILE PROPERTIES OF FULL HARD 301

Direction	Test Temp, F	Yld Str, 0.2% Offset, psi	Ten Str, psi	Elong, % in 2 in.
L	Room Temp	150,800	181,420	12.0
T	Room Temp	149,972	188,310	11.0
L	200	144,800	173,750	7.0
T	200	147,970	180,800	8.0
L	300	141,870	168,320	5.0
T	300	144,000	175,700	5.5
L	400	140,150	167,850	4.5
T	400	142,330	172,900	4.5
L	500	134,500	160,550	4.5
T	500	142,110	169,900	4.0
L	600	129,950	156,310	6.0
T	600	139,350	165,930	5.0
L	700	127,450	150,530	7.0
T	700	130,710	160,160	5.5
L	800	118,980	145,340	6.0
T	800	127,390	154,160	5.0
L	900	115,260	139,600	6.0
T	900	121,600	147,330	5.0

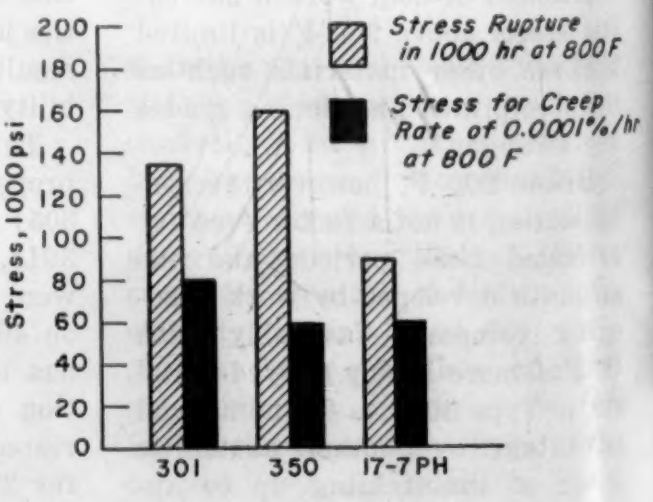
L—Longitudinal T—Transverse

ROOM TEMPERATURE PROPERTIES OF FULL HARD 301 AFTER 1000 HOURS AT INDICATED TEMPERATURES

Condition	Rockwell Hardness	Ten Str, psi	Yld Str, 0.2% Offset, psi	Elong, %	Mod of Elast, psi
Full Hard 301	Rc 40.5	181,420	150,800	12	23.9×10^6
1000 hr at 400 F	Rc 42	191,000	164,400	9	27.6×10^6
1000 hr at 600 F	Rc 42.5	192,500	166,300	10.5	26.8×10^6
1000 hr at 800 F	Rc 43	181,500	153,000	7.5	28.0×10^6



***Tensile strength** vs temperature for 301 stainless and four other alloys used at elevated temperatures.*



***Comparative creep** and rupture strength of full hard 301 at 800 F.*

Jet fuel pump uses filled nylon for . . .

Rotor—Cast aluminum rotor has 0.020-in. coating applied by injection molding. Cam is perforated with 80 holes through which the plastic flows to create a permanent bond. Coated journals run against anodized aluminum bearings.

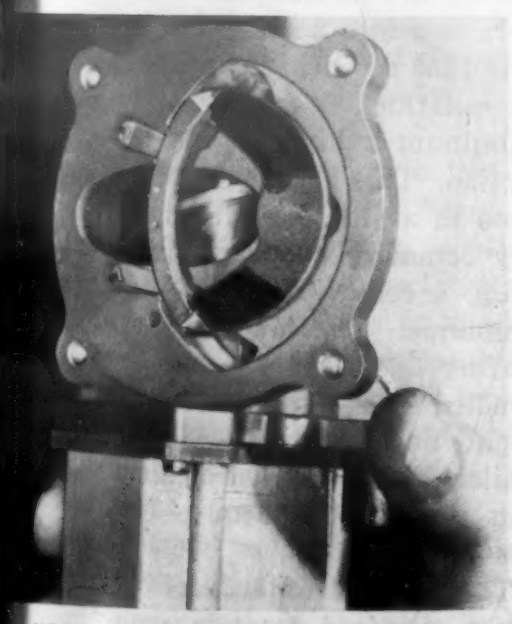
Shaft O-ring seal—Held against casing by 4-lb spring load, it revolves with shaft at 1000 rpm. The ring seats perfectly during the 1-hr dry run given all pumps after assembly. Other materials had to be lapped to fit or wore out rapidly.

Nylon filled with molybdenum disulfide was selected for seven different kinds of wear applications in this Whittaker Ratio-Flow pump.

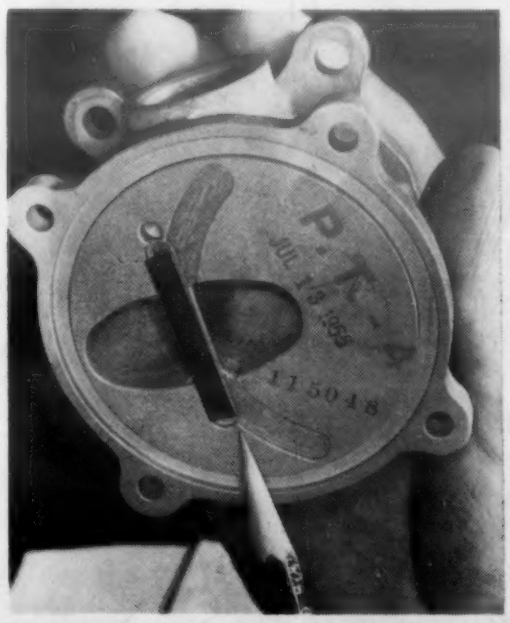
The miniature positive displacement pump is used for fuel transfer in aircraft and missiles and handles JP4 fuel at —65 to 100 F and pressures up to 200 psi. Since a pump may run after a fuel cell is dry, the wear parts must be self-lubricating. A high degree of dimensional stability is also required.

Among the materials tried previously were carbon, carbon-graphite and ordinary nylon. Carbon and carbon-graphite surfaces were easily damaged by the abrasives which often get into fuel. Nylon was not as wear resistant, not as resistant to fuel and moisture, not as easily and uniformly molded and not as suitable for close tolerances as the filled nylon.

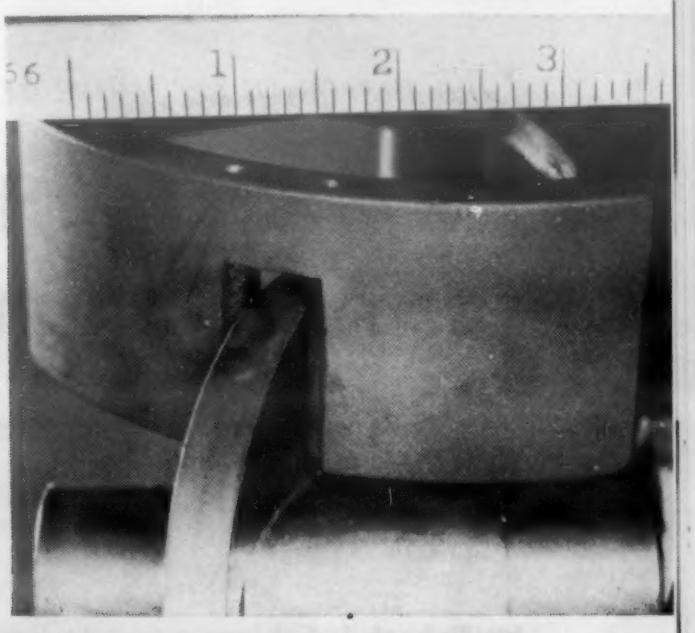
The molybdenum disulfide-filled nylon is known as Nylatron GS and is made by National Polymer Products, Inc.



"D" shuttle seal strips—Two "D" sections which bear against shuttle are shown partially pulled out. Filled nylon is also used for the two sleeve bearings that run against the shuttle pin in the cavity behind the shuttle (top center of photo).



Shuttle wear pad—Keystone section is held by springs against flat surface of shuttle which moves at 166 fpm. Unlike unfilled nylon, which was tried previously, filled nylon resists wear and maintains the flatness that is essential.



Roller shuttle seals—Two on a side, they bear on the coated cam, giving nylon-to-nylon contact. Filled nylon stands up better than unfilled nylon or carbon compounds previously used. Scale shown is in centimeters.

Aluminum Co. of America

***Truck and trailer** bodies are among potentially important applications for a new clear lacquer described in this article.*

Low viscosity cellulose acetate butyrate:

New Protective Lacquer for Aluminum

A single spray coat prevents dulling, staining and pitting in outdoor applications.

by Robert J. Fabian, *Associate Editor, Materials & Methods*

■ Because of its outstanding long term stability and weathering resistance, cellulose acetate butyrate coatings have been used for a number of years as protective coatings for specialized outdoor applications. Due to its relatively high viscosity, however, cellulose acetate butyrate has not been available in a form that lends itself to broad-scale lacquer applications.

The viscosity of any lacquer is directly influenced by the viscosity of its film former. Use of a high viscosity film former demands such a high degree of solvent reduction to achieve sprayability that the resulting lacquer, because of its low solids content, becomes economically impractical. Protective coatings for plastic molding compositions based on cellulose acetate butyrate, for example, have a solids content of only 5 to 7%.

To realize the full potential of these protective coatings, Eastman Chemical Products, Inc., has recently developed a low viscosity cellulose acetate butyrate, known as Half-Second Butyrate, which can be formulated into sprayable lacquers with high solids content. Lacquers based on this material have been developed by the Egyptian Lacquer Mfg. Co. Known as Clear Coating CH-64, the water white lacquer has proved superior in many respects (see table) to other clear air-dried lacquers previously used on aluminum.

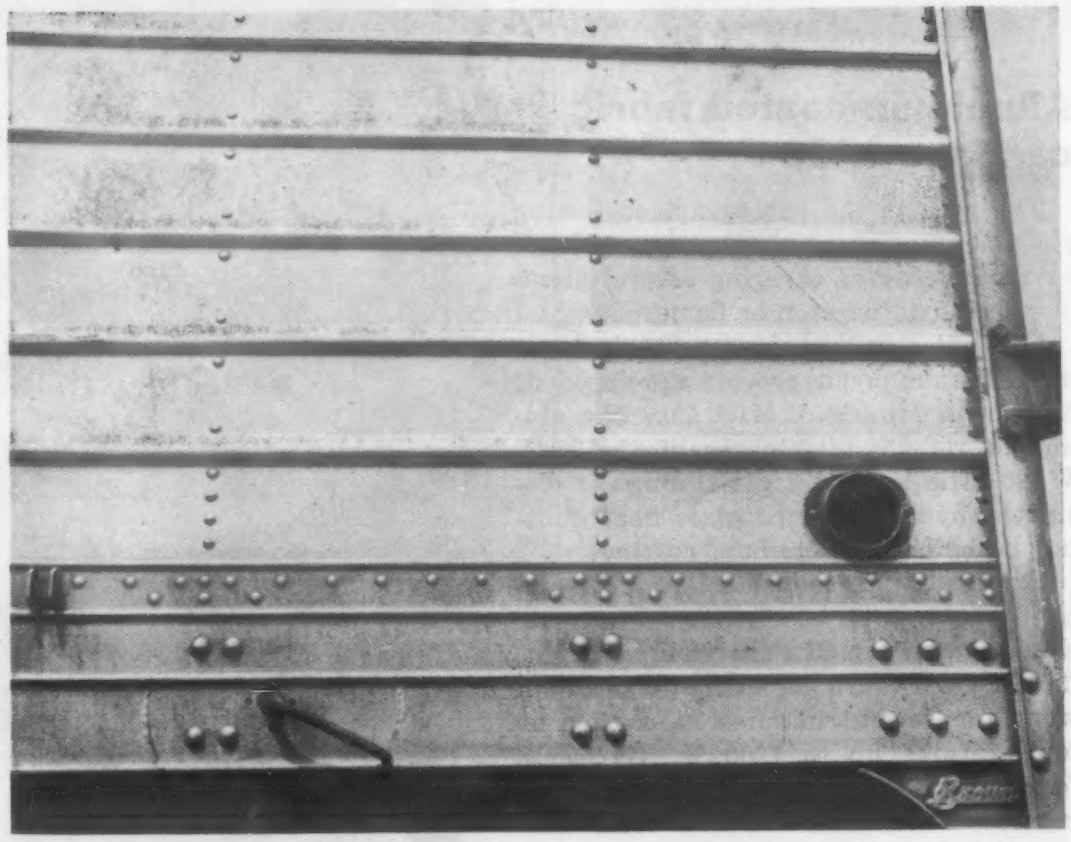
Normally, the lacquer is supplied with a solids content of approximately 18%. This content is usually cut to about 13% for spray or dip applications by reducing the formulation with thinners in a 5 to 2 ratio. Tests indicate that a coating approximately ½ mil thick is sufficient to give aluminum a high degree of protection. This thickness can be applied in a single application with any commercial spray equipment using a conventional double pass technique. The low flammability coating dries rapidly and can be handled in less than 15 min after application. Large commercial trailers can be coated in about 45 min for a total lacquer cost of less than $10.

The amount of surface preparation required depends upon the condition of the aluminum. New surfaces should be free from dirt and a thorough wash in a cleaning solvent is recommended. In many cases a solvent cleaning to remove fingerprints and grease is

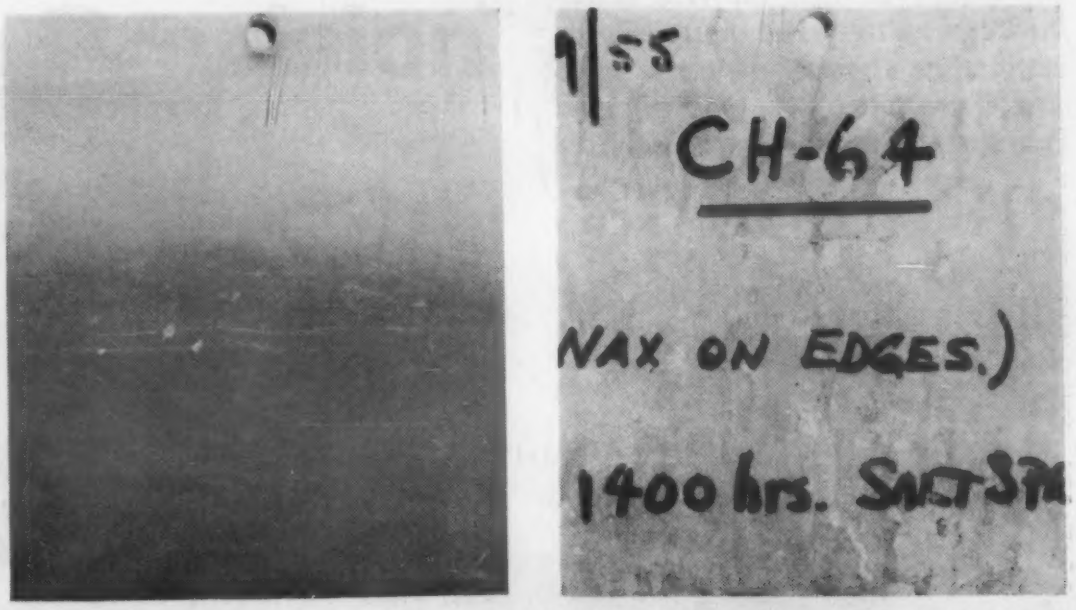
Why Protection Is Necessary

The outstanding corrosion resistance of aluminum has led to its use in a variety of applications for transportation equipment, building materials and outdoor furniture. Although aluminum will withstand extremes of weathering without suffering any structural damage, exposed surfaces lose their gloss and deteriorate after continued exposure. The gradual dulling of aluminum truck trailers and buses and the annoying rub-off of oxidized aluminum from outdoor furniture are typical examples of the deterioration encountered with unprotected surfaces.

Not only does continued weathering destroy the beauty of aluminum, but it also creates costly maintenance problems. Restoration of surfaces by brighteners is comparatively expensive. Also, microscopic pitting, which no amount of brighteners can ever repair, quickly gathers grit and dirt and necessitates frequent cleaning.



Comparative trailer panels *of uncoated aluminum (bottom) and aluminum coated with low viscosity cellulose acetate butyrate (top). Photo was taken after a 16-mo test covering 128,000 miles. Note corrosion pitting and dulling of untreated panel.*



Salt spray *exposure for 1400 hr had little effect on coated panel (left), but produced marked staining of uncoated panel (right).*

sufficient. A typical phosphoric acid pretreatment that has been found to inhibit corrosion under rigorous exposure conditions consists of: 3% (by weight) of 85% phosphoric acid, 20% water, 32% of 95% Tescol, and 45% butyl alcohol.

To date the three principal applications of lacquers based on Half-Second Butyrate coatings have been for aluminum truck and trailer bodies, window frames and storm windows and outdoor furniture. Other applications include street lighting standards, traffic and commercial signs, structural sections, boats and aircraft.

In tests conducted by a major trailer manufacturer, coated aluminum panels in the plain and 90 deg bent condition have exhibited no breakdown after 500 hr of both humidity and salt spray test. No yellowing or discoloration was exhibited after a gasoline wipe test.

PROPERTIES OF HALF-SECOND BUTYRATE COATINGS

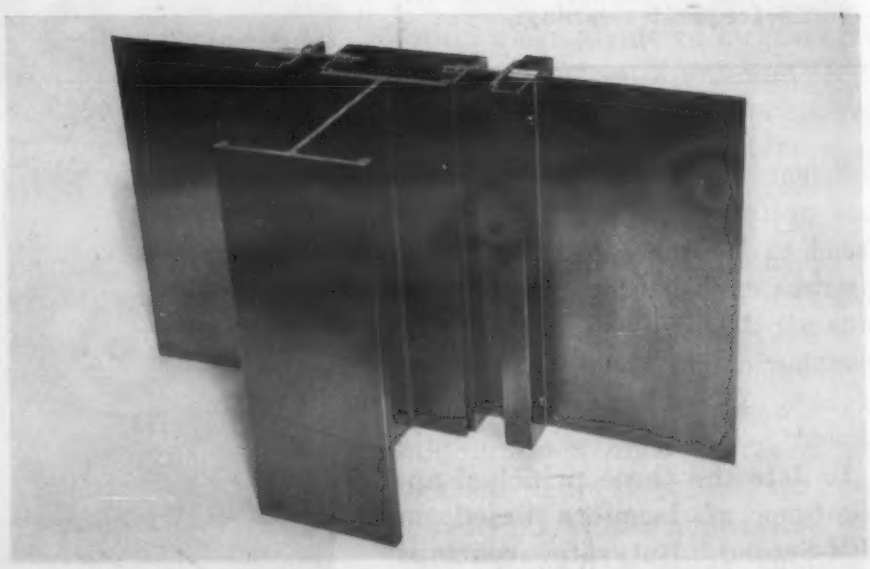
Exterior durability	Coated panels on truck trailer in excellent condition after 17 months of continuous testing.
Salt spray resistance	No film breakdown after 1400 hr salt spray test.
Humidity resistance	No film breakdown after 400 hr exposure in humidity cabinet maintained at 100% r.h. and 100 F.
Acid resistance	No film breakdown after exposure to 5% hydrochloric acid for 36 hr.
Weatherometer	No film breakdown after 1075 hr—equivalent to 1½ years of outdoor exposure.
Ultraviolet light	No color change after 150 hr exposure 13 in. from G.E. sunlamp bank.

Aluminum-coated fabric can take 1200 F

The man in the photograph is testing an aluminum-coated suit in a 1200 F oven. He entered carrying several pieces of wood that burst into flame.

His suit was coated with a thin layer of aluminum by a process developed at Minnesota Mining & Mfg. Co. The aluminum reflects nine-tenths of the heat. What little heat does get through is dissipated by the layer of glass fiber quilting beneath the aluminum coating.

Emergency personnel at airports and oil fields, as well as firemen, now wear similar garments. The fabric, lightweight, flexible and durable, permits them to work for several minutes at a time at temperatures up to 1200 F. Garments for less intense heat, e.g., for work near steel furnaces, are made from aluminum-coated light asbestos or aluminum-coated duck.

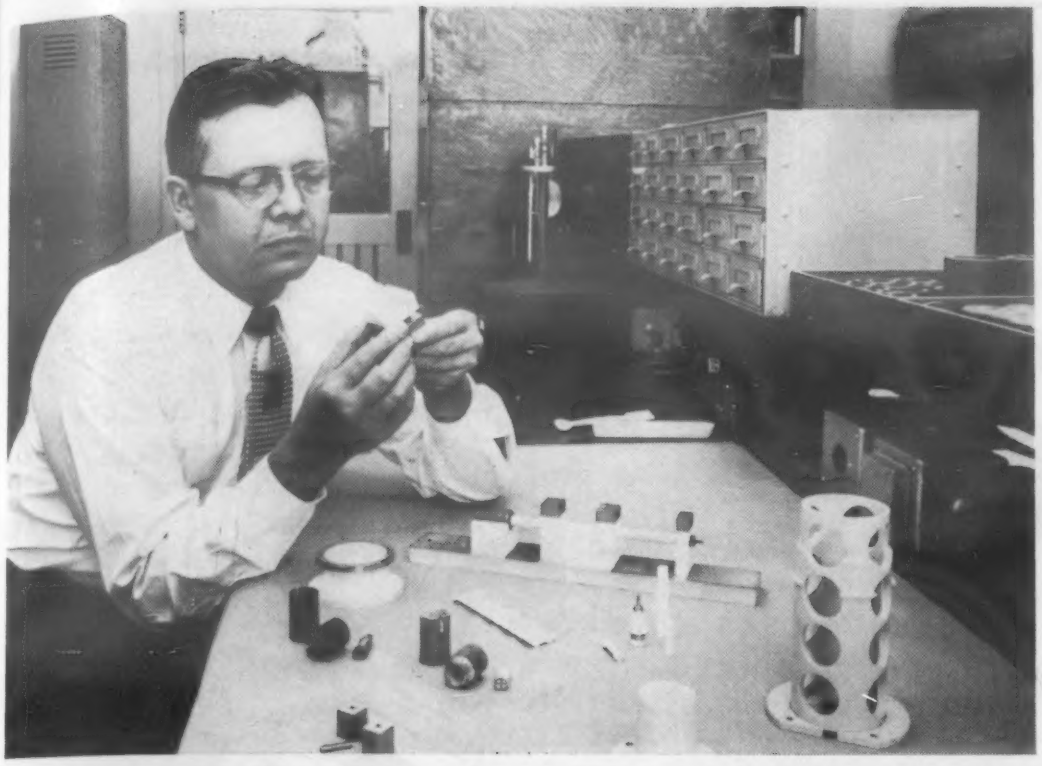


New building will use largest bronze extrusions ever made

The mullions (vertical window dividers) to be used in the Seagram Building in New York are the largest bronze extrusions ever made. Extruded from 400-lb billets and weighing up to 275 lb when finished, they easily exceed the usual commercial limit of 6 in. on cross-section diameter. The I-beams measure up to 26 ft 4 in. in length.

The entire sheath of the new building will consist largely of architectural bronze extrusions and rolled plate and will represent the first use of bronze in curtain wall construction. Bronze was chosen because it does not rust, has generally good resistance to corrosion, has good workability and ages to an attractive color. About 3,200,000 lb of bronze will be needed.

The ⅛-in. plate used for spandrels (horizontal floor dividers) also required a departure from usual brass mill practice. Dimensional tolerances are half the commercial tolerances, and a high degree of flatness must be achieved in rolling in order to prevent buckling and achieve uniform light reflection.



Complex shapes *of various ceramic compositions can be made with precision by new manufacturing techniques.*

Dimensional accuracy, close control of properties achieved with . . .

Tailor-Made Precision Ceramic Parts

As electronic components have become smaller and more precise, it has been necessary to develop ceramic parts with ever-decreasing tolerances on both dimensions and dielectric characteristics. Here is a report on what can be done today.

by **W. F. Janssen,** *Chemical Research, Bell Telephone Laboratories*

■ By newly developed techniques, ceramic parts can be produced with desired properties or dimensions held to a high degree of accuracy. Physical, electrical and mechanical properties more precise than those available in commercial ceramic parts can be obtained by close control of formulation and processing variables. Tolerances on physical dimensions can be held as closely as with machined metal parts by use of diamond wheel grinding techniques. Dimensional accuracy is vital in systems where a minor change of dimension on a ceramic part produces a change in dielectric behavior, which in turn can produce major errors in the functioning of the system.

Why Precision Is Hard to Get

Difficulties in producing precision parts are inherent in ceramic materials. Variations in raw materials and molding pressures during manufacture result in variations in green densities. During firing, chemical changes cause the molded parts to shrink to varying degrees depending on the proportions, kinds and particle sizes of the raw materials. This inconsistent shrinkage makes it difficult to produce ceramic components with highly reproducible characteristics and precise dimensions.

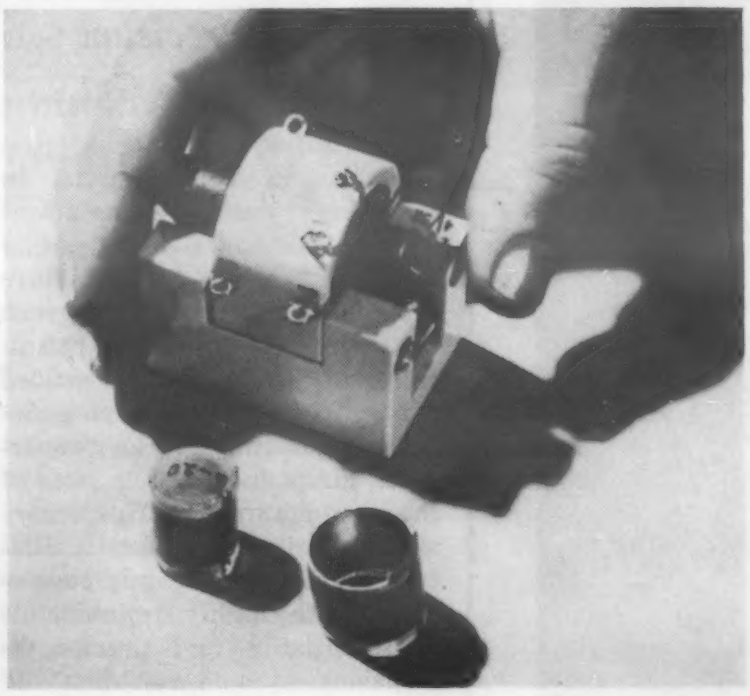
How it is done

Ability to determine and maintain highly precise physical, electrical and mechanical properties of a ceramic body is the result of 1) careful selection and rigid specification of raw materials and 2) close control over the mixing, forming and firing process.

Raw materials are selected on the basis of chemical composition and freedom from undesirable impurities. They must meet stringent requirements with respect to both density and particle size, shape and distribution.

Manufacturing processes are closely controlled to yield intimate mixing and large surface area for the inorganic ingredients. Intimate mixing decreases the distance between molecules of the material and speeds the solid state reaction. Temporary organic plasticizers and binders are also carefully chosen and distributed throughout the mixture. These factors affect the rate and extent of solid state reactions which occur during firing, and thus affect the quality of the end product.

In general, accuracy in physical dimensions is obtained by conventional grinding and other machine shop equipment which has been



Precision Ceramic Transformer

Service conditions for this transformer, which is used in the L3 coaxial carrier telephone system, require that its constants be held to an extraordinary degree of precision, and that temperature variation and aging effects be virtually eliminated.

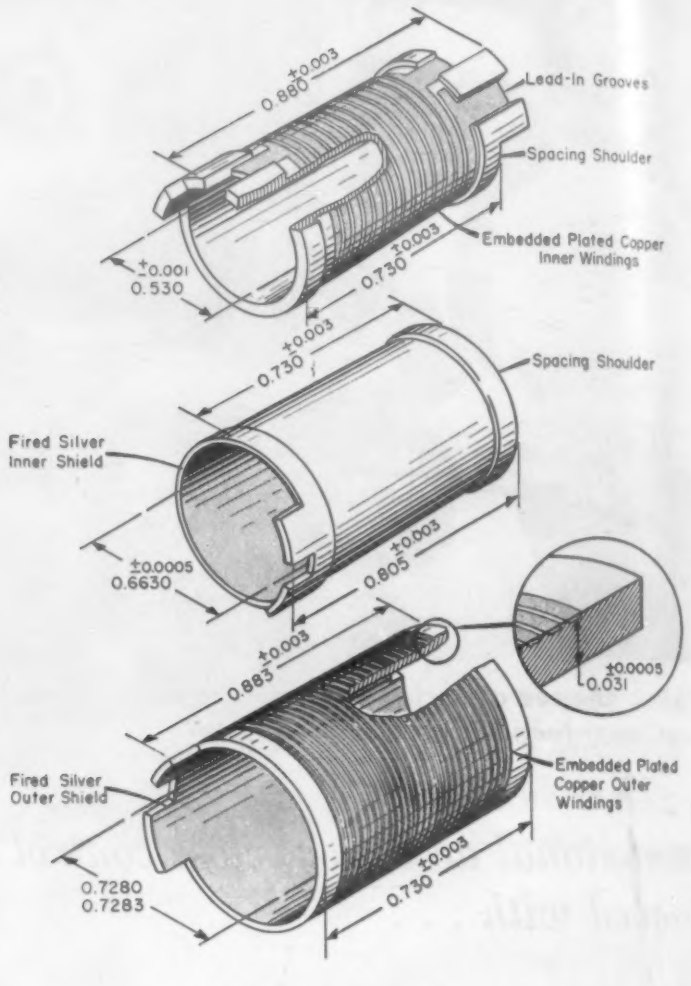
These requirements necessitated a complete redesign using entirely different materials from those used in conventional transformers. The accompanying table compares structural details of the new transformer with those of a conventional transformer. The new materials, in addition to having stability, low loss and good insulating properties, can be held to very close mechanical tolerances, making it possible to obtain the degree of electrical precision required.

With the exception of a honing operation on the i.d. of the coil forms and the final dressing operation after the parts are copper plated, all machining operations are done on special grinding machines equipped with fine grit bonded-diamond wheels.

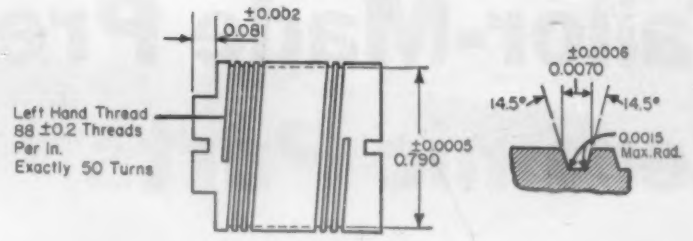
The major problem is production of the winding form, which is a threaded cylinder of special glass machined to extremely fine tolerances. The inner and outer surfaces of the glass form must be held to 0.0005 in. on concentricity. It was found that by holding ±50 millionths of an inch on the i.d., which is the base point for other dimensions, it was easier to meet the limits on other dimensions.

The accompanying sketch shows a composite view of winding forms, embedded copper windings and fired silver interwinding shields, and indicates some of the critical tolerances held.

INNER AND OUTER WINDING DETAILS



THREAD DETAIL



	Conventional Transformer	Precision Transformer
Core	Permalloy powder	Manganese-zinc ferrite
Winding form	Molded or fabricated plastics part	Threaded cylinders of special glass
Windings	Machine-applied insulated drawn copper wire	Plated copper embedded in special glass forms
Shielding	Copper or tin foil	Fired silver on special glass forms
Coil enclosure	Metal or plastics container	Steatite housing and cradle

adapted or converted to the use of wet diamond wheels. Accuracy in complex shapes is obtained by special chucking arrangements and new types of diamond tools.

By conventional methods of forming ceramics, minimum dimensional tolerances on parts as formed are about ±0.005 in. on dimensions up to ½ in. and ±1% on larger dimensions. By the Laboratories' controlled techniques as-formed minimum tolerances of ±0.0025 in. are practical on dimensions up to ½ in. and ±0.5% on larger dimensions. With diamond wheel grinding techniques virtually any tolerances desirable can be held.

By improving quality and uniformity throughout the ceramic

body, design can be made more flexible. Minimum radii can be smaller and walls can be thinner. For example, a steatite tube has been extruded with an 0.044-in. o.d. and an 0.035-in. i.d. By subsequent diamond wheel grinding, wall thickness could be reduced to about 2 mil.

Materials and tolerances

Precision techniques are applicable to five principal types of ceramic materials used in the communications industry, namely: ferrites, titanates, steatites, high alumina bodies and fused silica. Though in most cases primary considerations are their electrical characteristics and how these affect circuit characteristics their role as structural members is also important.

Ferrites—Difficulties in obtaining precision in both properties and dimensions can be illustrated by the characteristics of ferrites, compounds formed from iron and other oxides and used as magnetic core materials in high frequency circuits. More specifically:

1. In the usual manufacturing process, i.e., mixing the oxide powders, calcining the mixture, adding a binder and pressing, it is difficult to hold dimensions much closer than $\pm 2\frac{1}{2}\%$ for die-determined dimensions such as the diameter of a cup. Thickness of the cup depends on fill control and usually varies more than this. When "fixed" (fired), ferrites usually shrink 12-14%, some shrinking as much as 20%. Shrinkage is a function of the powder, forming pressure, temperature and time, and can vary over a wide range. Careful control over raw materials, all details of mixing and forming, and furnace temperature is therefore important.

2. In a ferrite part of complex cross section, where densities may vary, or in a part where composition of the surface changes in cooling, the temperature-permeability curve may be a composite of two or three curves corresponding to compositions in different parts of the core. Hence, variation of permeability with temperature is a difficult parameter to control precisely.

In ferrites used in transformers and inductors, μ (permeability) and Q (absence of losses) are of particular importance. To tailor-make a part for a particular application, one property can sometimes be controlled more closely by sacrificing others. For example, higher permeability can be obtained by fixing cores for longer periods of time, but shrinkage will be greater and Q may be lower.

In high quality inductors and transformers where high Q is important, tolerances on permeability may often be broad, e.g., μ may range all the way from 1000 to 2500. In this type of transformer or inductor, an air gap is usually used to control effective permeability so that permeability of the ferrite material is not critical. The μ-Q product, however, must exceed a specified minimum. Reports from France and England on work done by Guillaud indicate that ferrites made of specially prepared and purified raw materials may yield μ-Q products up to two or three times those of ordinary commercial products.

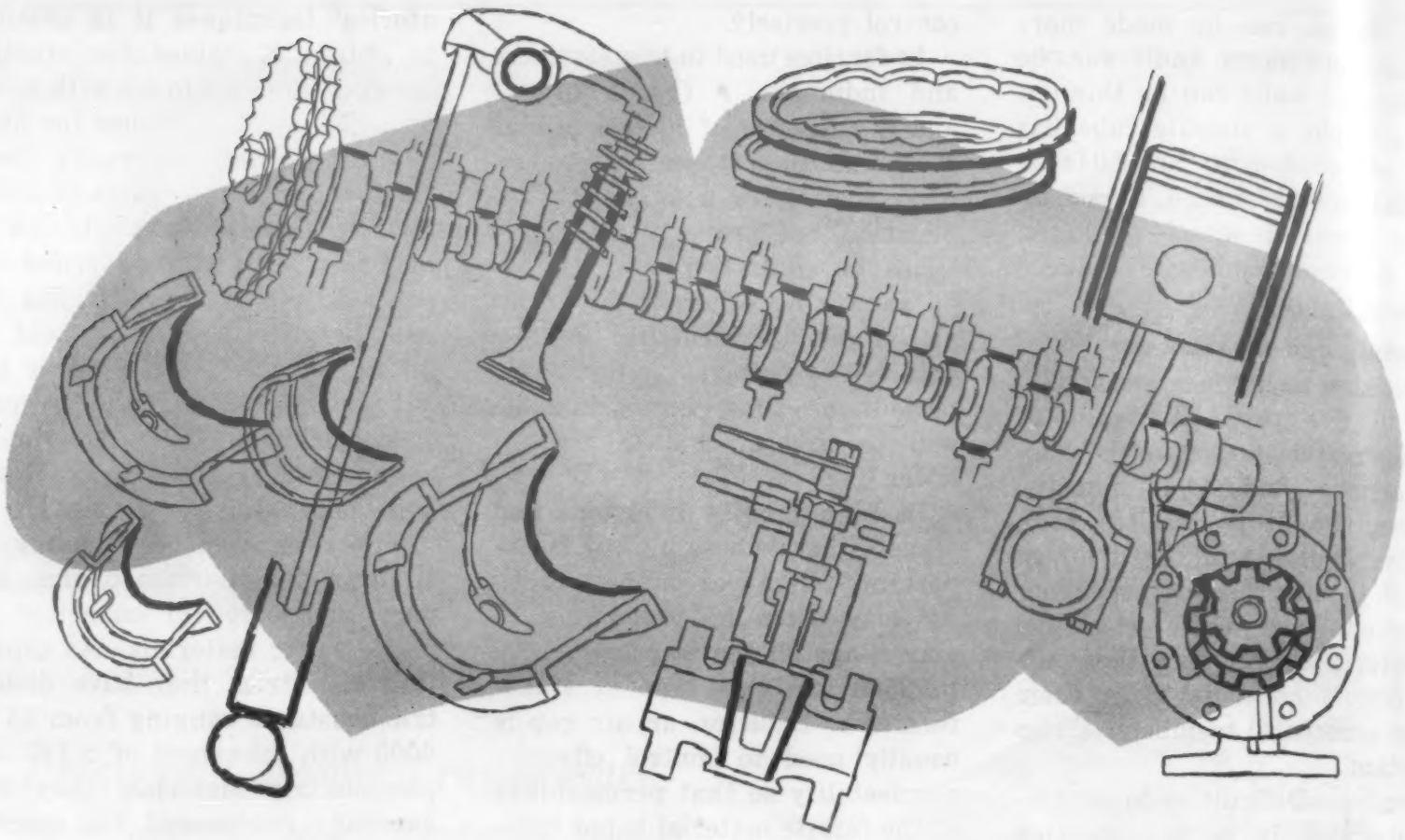
In transformers and inductors where high permeability *is* required, values need not usually be precise. In pulse transformers, for example, permeability limits may be $\pm 50\%$. However, in other instances closer tolerances are useful, particularly for core manufacturers who cannot assume their customers will be able to design around wide tolerances. Commercial manufacturing tolerances on initial permeability are on the order of $\pm 10\%$.

Other ceramics—Steatites, composed principally of magnesium silicate, and high alumina bodies, containing more than 85% aluminum oxide, have similar dielectric properties. The alumina bodies, however, have both higher temperature resistance and much higher mechanical strength. Illustrative of the accuracy possible in obtaining specific values for various properties are the tolerances which can be held on dielectric constants (K). By the Laboratories' techniques it is possible to obtain K values for steatite ranging from 5.0 to 6.5 with tolerances of ± 0.3. K values for high alumina bodies can range from 7.5 to 9.5 with tolerances of ± 0.4. Specific gravity of steatite can be held to 2.98 ± 0.02. Thermal expansion, which is controlled by specific gravity, can be held to $7.7 \times 10^{-6} \pm 0.01 \times 10^{-6}$ over the range of 85-1380 F. Other properties can be held to tolerances closer than commercially available, depending on the need.

Titanates, composed mainly of titanium and barium oxides, are used primarily for capacitor or piezoelectric materials. As capacitor dielectrics they have dielectric constants ranging from 15 to 6000 with tolerances of $\pm 1\%$. As piezoelectric materials they are generally engineered for specific values. Typical of the values obtainable and the tolerances which can be held are:

K	$500 \pm 1\%$
Q	$140 \pm 2\%$
Mechanical Coupling Coefficient	$0.225 \pm 1\%$
Young's Modulus, dynes/sq cm	$1.25 \times 10^{12} \pm 1\%$
Specific Gravity	$5.30 \pm 0.5\%$

***Close control** over processing gives reproducible properties. Here a high alumina ceramic is shown being tested for workability.*



Current applications *of sulfurizing are illustrated by artist's sketch.*

Sulfurizing—New Surface Treatment—Reduces Scoring and Seizing

Developed originally in France, this new salt bath process is highly effective for iron and steel parts that must operate under boundary lubrication conditions.

by George B. Troup, *Vice President and General Manager, Lubri-Case, Inc.*

■ Wherever metal-to-metal rubing contact—sliding, rotating or reciprocating—presents boundary lubrication problems, sulfurizing should be considered. Although the process does not significantly lower coefficient of friction, sulfurized parts definitely gain resistance to scoring and seizing.

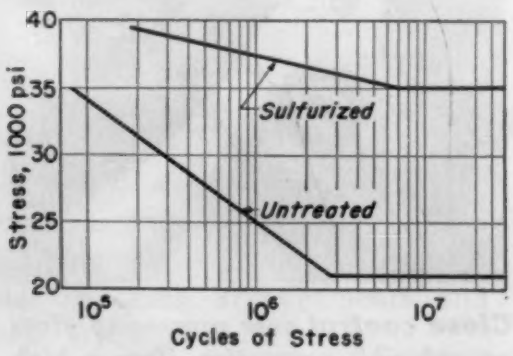


***Fig 1**—Fatigue comparison of sulfurized and untreated 1018 steel.*

Sulfurizing is essentially a salt bath treatment at 1040-1080 F which increases the sulfur content of ferrous metals to controllable depths beneath the surface. The active diffusing element, sulfur, is present in an incompletely oxidized state in a molten bath of alkali metal cyanide and neutral salts. Immersion time may vary from a few minutes to 2 hr, depending upon the material and the depth of case desired.

The method was originally conceived in France and has experienced steady growth there for over five years. Industrial development has also been under way in Great Britain by Imperial Chemical Industries, Ltd. and, more recently, in the United States by Lubri-Case, Inc.

Why sulfurize?

Sulfurizing was developed to overcome an important limitation of conventional anti-weld films—their tendency to undergo continuous removal under extreme boundary lubrication conditions.

Conventionally, a nonscoring film between ferrous metals is achieved by 1) metallic deposits or chemical conversion coatings, which owe their effectiveness to high hardness or lubricant-retaining pores, or 2) anti-weld lubricant additives such as compounds of sulfur, chlorine and phosphorus (dissolved oxygen in lubricants also forms effective films). Under extreme boundary lubrication conditions, however, anti-weld films tend to be removed by wear—permanently if they are coatings,

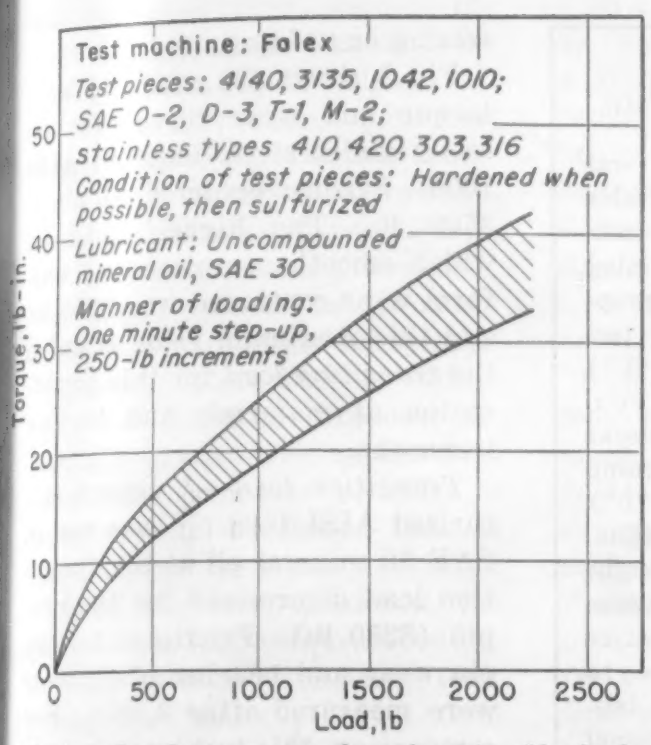


Fig 2—*Load-torque envelope for 12 sulfurized steels. Loading was 1 min step-up.*

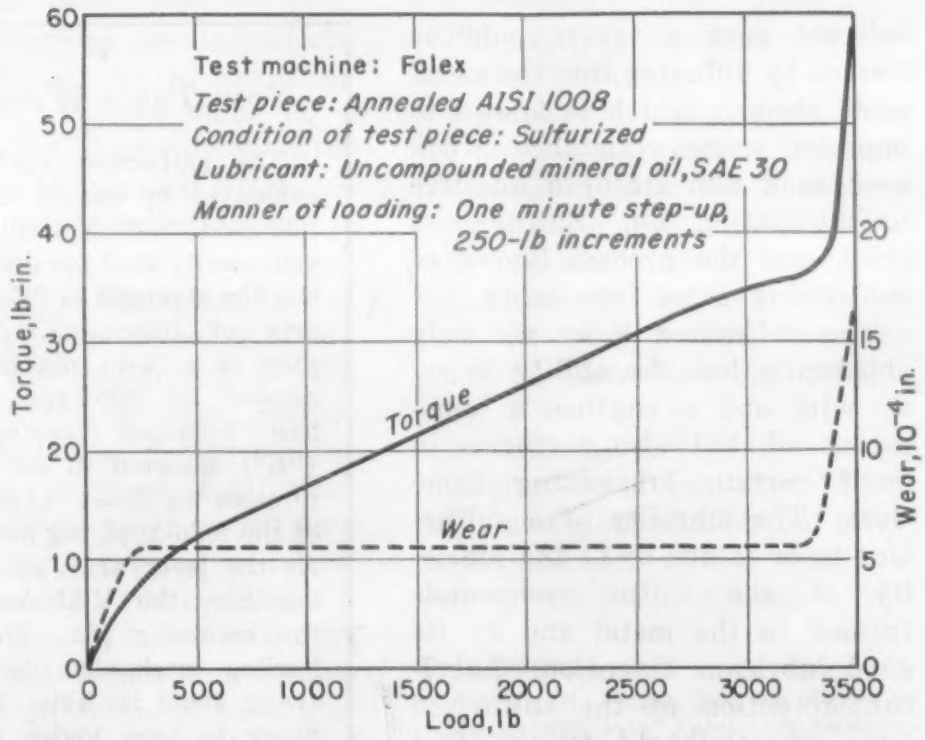


Fig 3—*Load-torque and wear curves for sulfurized 1008 steel. Loading was 1 min step-up to seizure.*

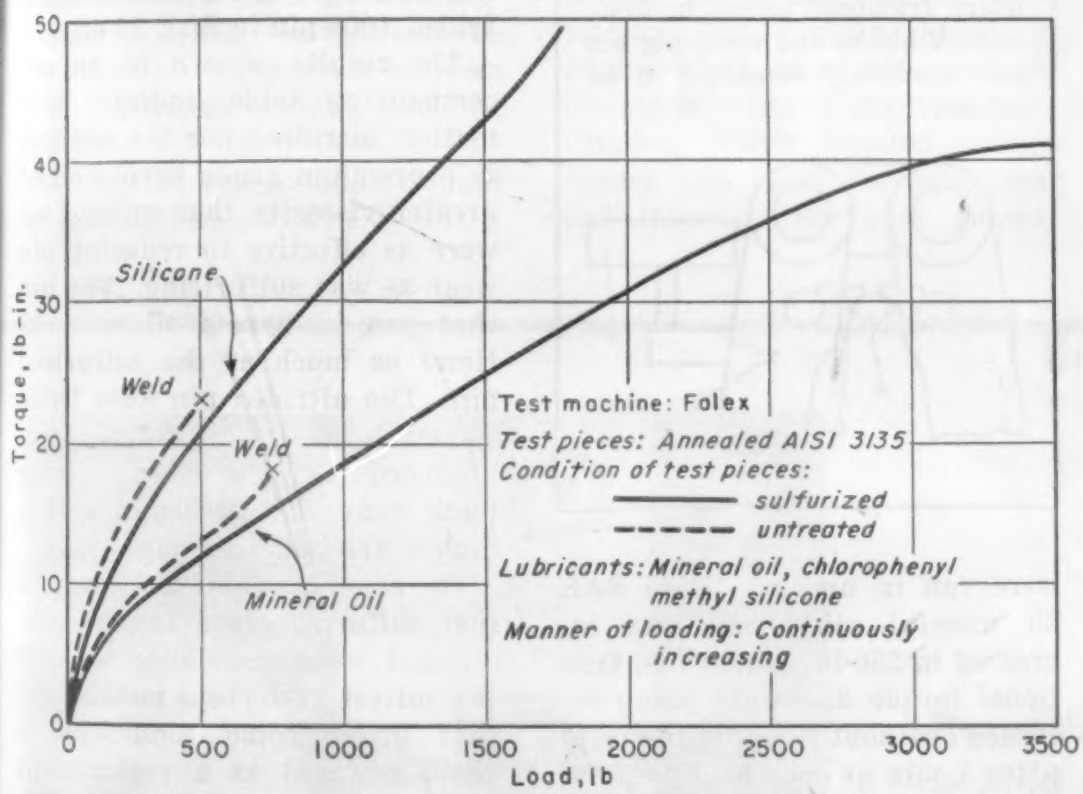
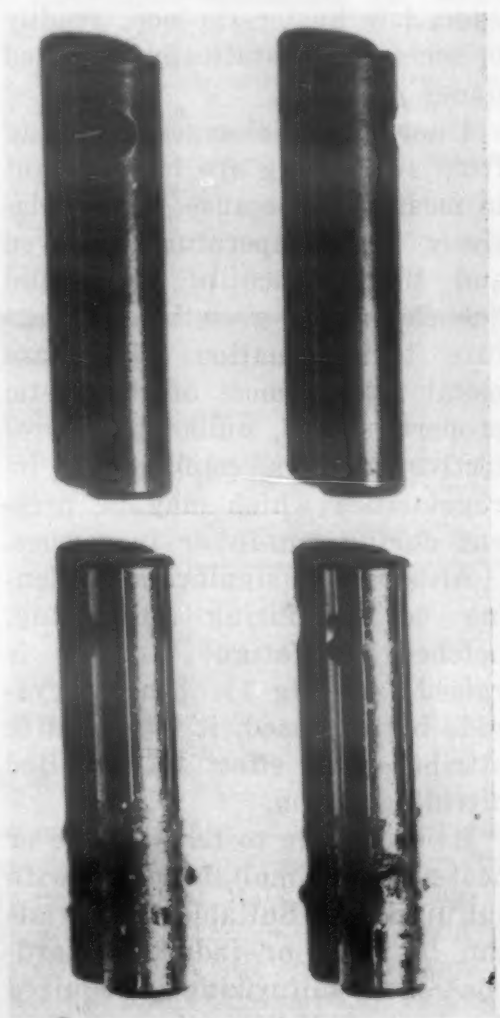


Fig 4—*Load-torque curves for sulfurized and untreated pins using mineral oil and chlorophenyl methyl silicone as lubricants. Load was continuously increased.*

HOW SULFURIZING COMPARES UNDER TRANSITION LOAD

Pin Treatment—Oil	Torque, lb-in.	Block scar, in.	Pin wear, in.
Sulfurized—Mineral Oil	36	0.0320	0.0008
None—Hypoid Oil	34	0.0320	0.0105
Nitrided—Mineral Oil	50	0.0374	0.0015



Test pins *after run graphed in Fig 4. Pins run in silicone fluid are at left. Sulfurized pins (top) were photographed after loading at 1500 lb (silicone fluid) and 4500 lb (mineral oil).*

and temporarily if they are compounded oils and are given enough time to reform. Where compounded oils cannot be used or where such films cannot be regenerated, progressive galling to seizure is inescapable.

The logical solution to this problem apparently was to form an integral layer of substantial thickness on the metal which would react chemically with the lubricant to strengthen the oil film and would also provide some protection under dry conditions. It was

believed such a layer could be formed by diffusing into the metal some element which is known to improve score resistance when used as a film strength additive to lubricating oil. Sulfur was tried, and the process known as sulfurizing came into being.

The sulfurized layer not only apparently has the ability to react with and strengthen a lubricating oil, but also performs in itself certain lubricating functions. The lubricity of a sulfurized layer is due to 1) the lubricity of the sulfur compounds formed in the metal and 2) its good lubricant retention. Lubricant retention of the sulfurized layer is attributed to the fact that ferrous sulfide (one of the compounds formed), which has a wide, low hysteresis loop, readily becomes electrostatically polarized under pressure.

Dimensional changes resulting from sulfurizing are insignificant in most cases because of the relatively low temperature involved and the absence of any rapid quench, grain growth or structure transformation. The base metal retains most of its elastic properties, and, unlike hard protective coatings, conforms to irregularities which may be present during run-in or in service.

Although no significant hardening occurs during sulfurizing, notched bar fatigue strength is raised (see Fig 1). Since a cyanide bath is used, it is logical to attribute this effect to a limited nitriding action.

It is possible to temper, age or heat-shape simultaneously with sulfurizing. Suitable materials can be flame or induction hardened after sulfurizing if required for improved strength.

How effective?

Effectiveness of sulfurizing has been evaluated by several different tests—all making use of the Falex lubricant testing machine described elsewhere in this article. Results of these tests, which differed primarily in the manner of loading, are described below.

Step loading — Sulfurized pins (hardened first when possible) were run in uncompounded SAE 30 mineral oil. Load was increased in 250-lb increments, frictional torque and wear being recorded (without stopping the test) after 1 min at each load.

The envelope of load-torque curves obtained for 12 different steels is shown in Fig 2. The envelope is not continued beyond 2250 lb because a broader scatter of torques is encountered above that load (it is believed that the conformability of the metal, as controlled by its yield point, introduces a variable which is more a measure of mechanics than of lubrication). There are no comparative curves for untreated pins because welding occurs almost immediately. Thus, the envelope demonstrates that a broad range of steels can be effectively sulfurized to permit high loads without seizing or welding.

Fig 3 shows the complete load-torque and wear curves for an easily galled steel, annealed AISI 1008. Seizure occurred at about 3500 lb. The highest load at which smooth operation and uniform wear continued was 3250 lb, and this maximum value is called the *transition load* for this combination of materials and loading technique.

Transition load—A second sulfurized AISI 1008 pin was run in SAE 30 mineral oil at the transition load determined for the first pin (3250 lb). Frictional torque, pin wear and bearing block wear were measured after 3 min. For comparison, this test was also run on an untreated 1008 pin in SAE 90 hypoid oil and a salt bath nitrided 1008 pin in SAE 30 oil.

The results, shown in an accompanying table, indicate that neither nitriding nor the additive in a premium grade hypoid oil of greater viscosity than mineral oil were as effective in reducing pin wear as was sulfurizing. The pin that ran in hypoid oil wore 13 times as much as the sulfurized pin. The nitrided pin wore twice as much as the sulfurized pin, produced 17% greater bearing block wear, and developed a 40% higher frictional torque.

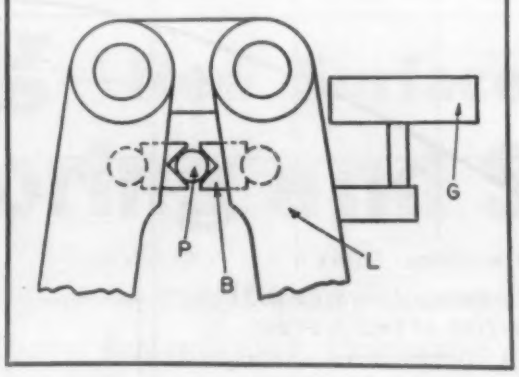
In general, this test showed that sulfurizing can impart substantial wear resistance to even the softest of ferrous metals, and that under some conditions it could be used as a replacement for expensive and corrosive film strength additives.

Continuously increasing load—Load-torque curves (see Fig 4) were obtained for sulfurized and untreated AISI 3135 pins run both in mineral oil and in a recently developed chlorophenyl methyl silicone fluid which is claimed to be more receptive to additives than methyl silicone. Because of the rapid seizure of the untreated pins, load was increased continuously rather than by steps.

The effectiveness of sulfurizing in delaying seizure is evident. However, the slopes of the curves show that up to the point where

How Tests Were Run

The sulfurized surface was evaluated by use of the Falex lubricant testing machine conventionally used for determining the film strength or "E.P." property of lubricants. The test piece is a ¼-in. dia pin ("P") rotated at 290 rpm between two V-shaped bearing blocks ("B") inserted in self-aligning recesses in lever arms ("L") of the load-applying mechanism. As the lever arms are brought together, the V-blocks squeeze the revolving pin. The entire loading mechanism is free to swing about its axis. This tendency to turn under frictional forces is resisted by a sylphon-operated gage ("G") which registers frictional torque in lb-in. Both V-blocks and revolving pin are completely immersed in an oil cup.



the untreated pins welded the friction coefficient was not reduced significantly by sulfurizing. It is an established fact that under boundary lubrication conditions there appears to be no functional relationship between friction and wear; hence, boundary lubricants cannot be properly rated solely in terms of friction coefficients. Nevertheless, sulfurizing has found its broadest acceptance in cast iron applications where the graphite provides a lower friction coefficient than is characteristic of steels.

In all the tests described, the slope of the load-torque curve decreased as load increased, indicating that under pressure (and probably dependent on temperature) a reduction in coefficient of friction occurs. As mentioned previously, it is believed that a chemical reaction takes place between the sulfurized surface and the lubricant and that, through this reaction, the role of film strength oil additives is performed.

Of course, laboratory tests such as those described merely indicate a trend or act as a means of judging the relative value of a process. Until correlated with field tests, they do not guarantee success in actual operation.

Applications

A major field of application for sulfurizing is engine parts, where "scuffing" is recognized as the most rapid form of wear. Sulfurizing is particularly effective for parts where reversal of direction causes interruption of the oil film, such as piston rings and cylinders, rocker arms and two-cycle piston pins. Bearing and cam lobe surfaces of cam shafts and chilled iron valve lifter faces have also been improved by sulfurizing.

Sulfurizing has also permitted greater speeds and reduced maintenance for certain kinds of pumps which must rely upon the limited lubricity of the fluid being handled. Parts treated include casing and gears for spur gear and internal spur gear pumps; and screws for screw pumps.

Potential applications for sulfurizing include:

1) Enclosed electrical machinery and heat treating furnaces which often lack the benefit of oxygen in their lubricants.

2) Machine parts involving metal-to-metal rubbing contact, such as plug valves, injection plungers, sleeve bearings and link pins.

3) Mill and factory wear parts, including tools and dies, which may be subject to marginal lubrication and can, if they seize, result in costly shutdowns.

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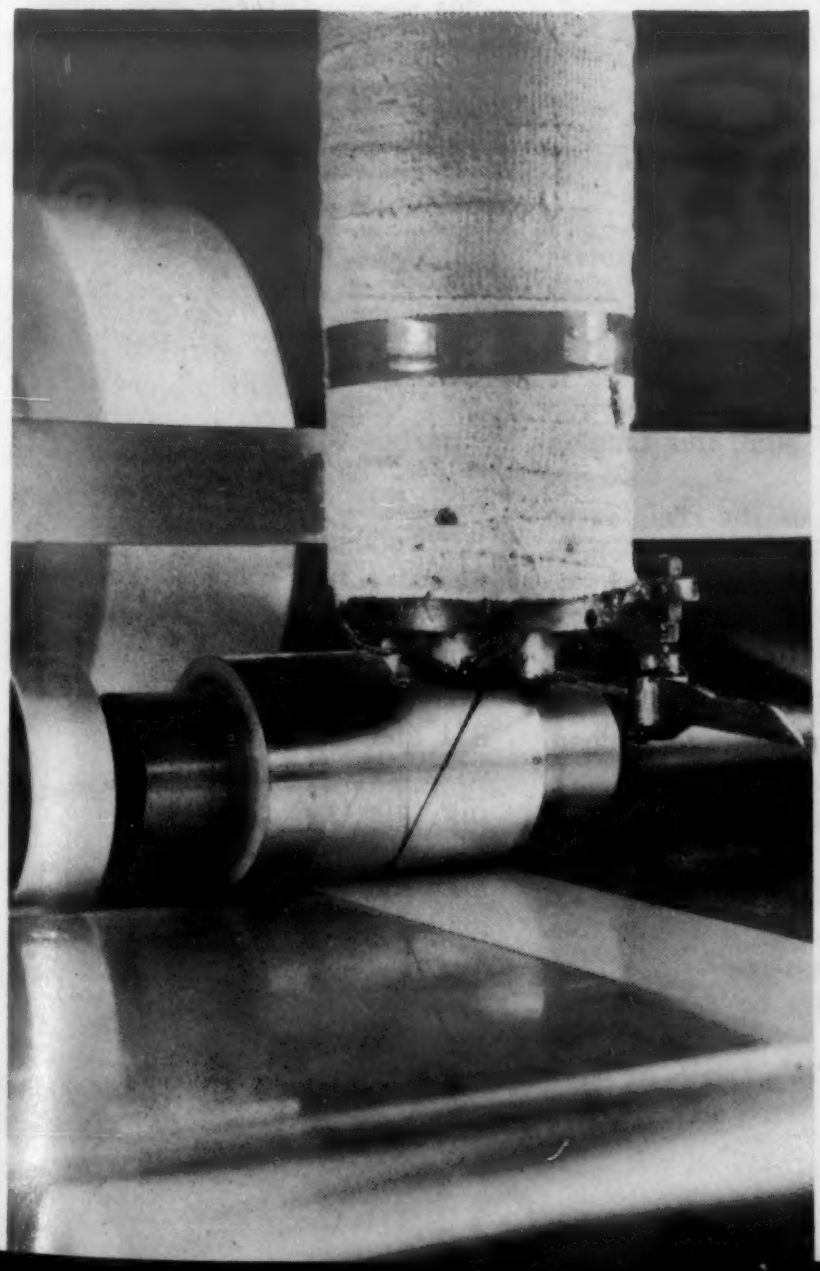
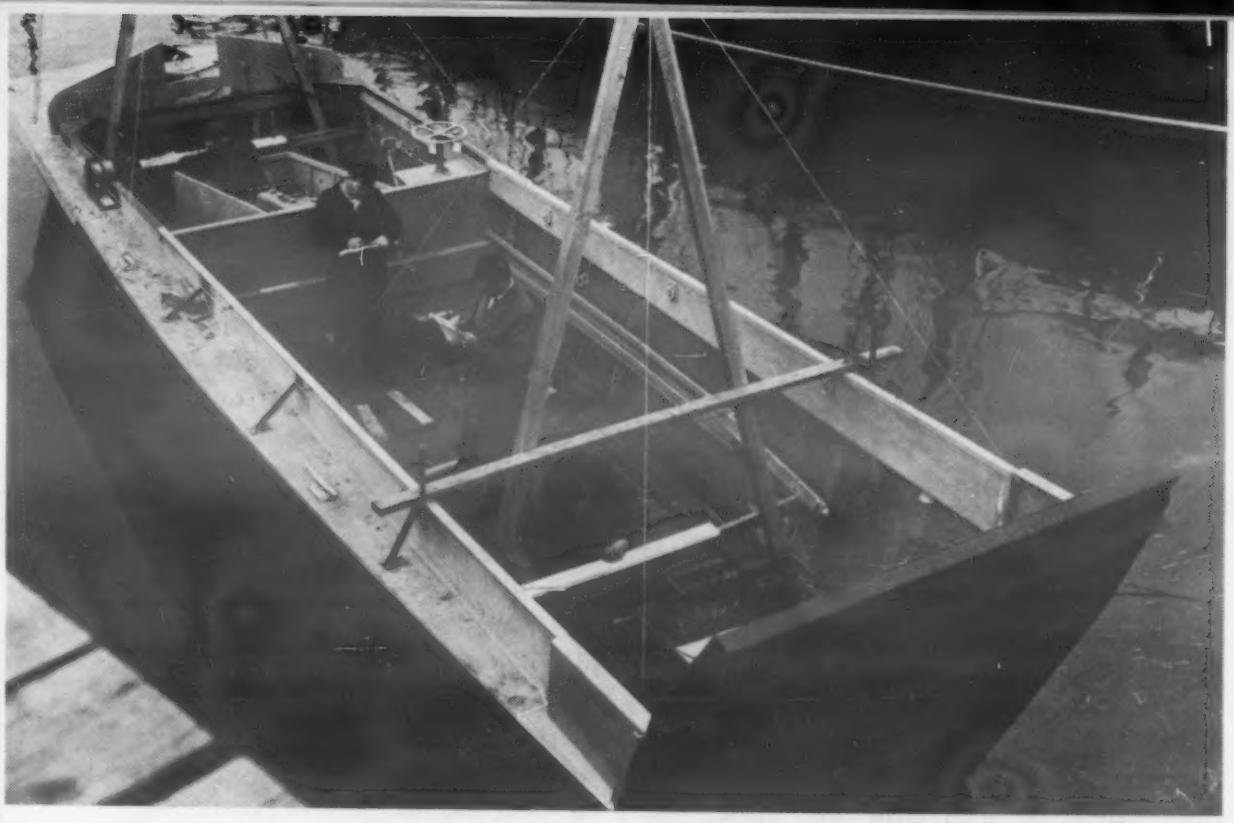


MATERIALS AT WORK

Polyethylene film sealed in a hurry

Polyethylene packaging film can be sealed continuously at speeds of 500 fpm or more by a molten bead technique developed at Bakelite Co., Div. of Union Carbide & Carbon Co. A hot filament of polyethylene is extruded between the two layers of film at the sealing line. Conventional methods, which apply heat from the outside, can seal 10-mil film at a maximum rate of 25 fpm and 1½-mil film at 150 fpm.

The polyethylene resin is heated in an extruder to about 480 F and forced out at the rate of about 1½ lb per hr. Just enough pressure to flatten out the molten bead between the two films is applied to the rollers through which the film passes after picking up the bead. The new technique will seal polyethylene film of almost any thickness and can also be used to seal polyethylene-coated paper, polyethylene laminates and paper.



Lunn Laminates, Inc.

***Predictable design strength** has become increasingly important as applications for glass-reinforced plastics have become larger and more complex.*

Parallel fibers + better glass-resin bond produce . . .

Stronger Reinforced Plastics

by James W. Case,
Research and Development Div., Navy Bureau of Ordnance

■ Use of nonwoven parallel glass mat, finished and bonded with an epoxy type solvent-solution, can double flexural strength and triple elastic limit of reinforced polyester laminates. This improvement is obtained by 1) the parallel positioning of the fibers to gain the utmost strength and elasticity from the glass, and 2) replacing conventional organic sizes and lubricants with a varnish that both coats and bonds the fibers.

Structure of a laminate

The basic elements in a reinforced laminate are the glass fibers, the resin, and the adhesive layer at the glass interface (see Fig 1). The glass fibers are the load bearing element. Though remarkably strong and elastic, they must be stressed parallel to their axes in either tension or compression to use most effectively their strength. Normally both forces would exist in a laminate under bending stress with compression on the concave side and tension on the other.

The function of the resin is to hold the fibers in a constant working relation to each other. When the fibers are under tension or compression, the resin should equalize the load between them so that they assume the total load collectively. Also, the resin braces the fibers apart at an infinite number of points to assure their performance as columns.

The strength of the adhesive bond at the glass-resin interface can not generally be determined. However, the strength of the resin is measurable. Therefore, in order to accurately predict the strength of laminates, the adhesive bond should be stronger than the resin.

Improved adhesion

In addition to the strength advantage gained in using glass fibers in a parallel geometry, elimination of weaving or twisting permits planned bonding agents to be used in place of conventional fiber spinning compounds. This is advantageous since the unpredictable strength of the adhesive layer could be due to: 1) organic sizes and lubricants applied in commercial spinning processes or 2) reaction of moisture and oxygen with the surface-active glass in such manner as to be detrimental to any succeeding de-sizing or finishing process designed to provide necessary glass-resin adhesion.

On the basis of these assumptions, the Navy Bureau of Ordnance established a project to investigate use of parallel fiber type reinforcements and to test various types of nascent fiber finishes. Instead of collecting the fibers in a 204 filament strand as in commercial processes, fibers were collected in a near-parallel mat on a drum. After a fiber mat of sufficient thickness was collected on the drum it was removed as a rectangular sheet, ready for laminating.

To test the types of finishes, the fibers were sprayed between the furnace bushing and the drum surface with solvent-resin solutions. the resulting varnish film coated the entire fiber surfaces. By producing "posts" between the fibers, the resin held the fibers together at necessary intervals.

The final binder system adopted was a blend of epoxy resins (Epon 834 and 562) in a 40% solution with acetone. The results of tearing this type of mat apart (Fig 2) indicate that in spite of the high adhesion of epoxy resins to glass, the resin bridges separated at the glass surfaces rather than at the "waist" of the bridge.

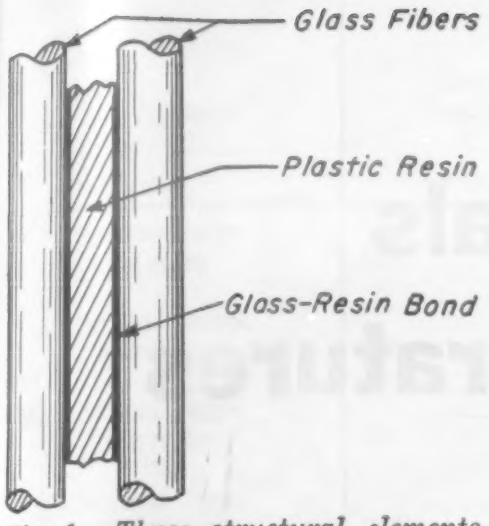


Fig 1—*Three structural elements of plastics laminate.*

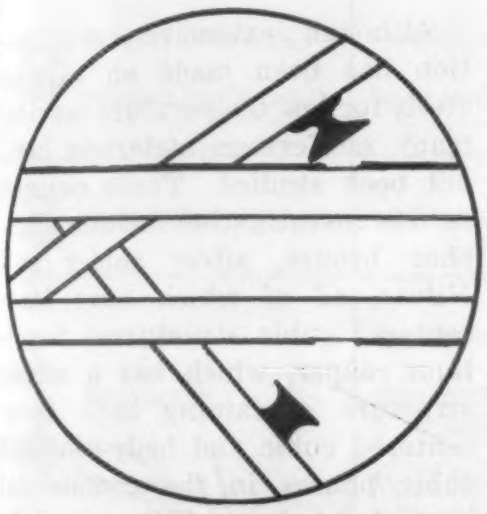


Fig 2—*Unsatisfactory bond is shown by separation at the glass-resin interface instead of separation at the "waist" of the resin bridge.*

Though the mat was considered to have sufficient mechanical strength for handling and lamination, there are still improvements in finishes to be made.

Polyester laminates

All test laminates were made by laminating seven plies of the parallel glass mat with the fibers at 90 deg in adjacent plies. Flexural tests were made and results compared with those from 181-114 glass cloth laminates. As shown in the accompanying table, flexural strength values for the parallel mat reinforced laminates are approximatey twice those of the glass cloth-reinforced laminate and elastic limit is approximately three times as high.

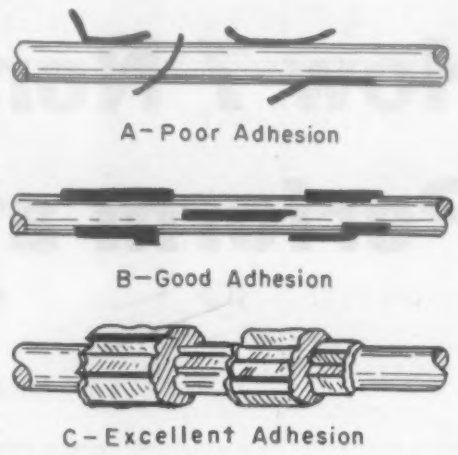
On the L/D chart taken from the flexural testing machine the curves for the glass cloth laminate were typical; i.e., they departed from straight line proportionality at a point somewhat below 50% of the ultimate strength. Beyond this point, the material is obviously damaged and cannot return to its original shape when the load is removed. It follows that with this type of material, design emphasis should be placed more on elastic limit than ultimate strength.

In addition to higher strengths, L/D curves for the parallel glass laminates were quite different in that they did not depart from straight line proportionality until just short of ultimate strength. This behavior is uncommon for glass-reinforced laminates, and reflects much more closely the elasticity of glass itself.

New Method Evaluates Strength of Glass-Resin Bond

A visual method of evaluating the adhesive bond between glass fibers and resins was developed during the NBO project. The method is based on the amount of resin still adhering to glass fiber surfaces after a laminate is torn apart. Examination under a low power microscope of separated plies of a laminate having relatively poor interlaminar strength shows the fibers stripped clean of resin. Examination of other laminates shows varying amounts of resin adhering to the fibers.

Ideally, an accurate method of numerically grading laminates could be based on actual count of resin chunks per unit area, using a shadowgraph of fibers at the fractured laminate surfaces. For the purposes of this project, however, this work was not carried out. Instead, a rough grading system was used, which is illustrated in the accompanying sketch.



Condition A illustrates the condition seen in ordinary laminates, attributed to poor bonding agents on the glass. *Condition B* illustrates a considerable improvement in adhesive quality of the bond. This is the condition attained with the epoxy solvent-solution finish. *Condition C* illustrates the ideal situation, where all fracture takes place in the resin itself. This condition was never attained in the course of the project.

The effects of these varying degrees of adhesion on flexural strength are shown in the following table:

Laminate Number	Visual Classification	Flexural Strength, psi
7	A	29,900
11	A	48,300
13	A	56,100
16	A	30,100
18	A	33,300
23	A	43,700
67	B	82,500
85	B	85,800
96	B	83,500
103	B	93,400
118	B	82,300
121	B	97,300

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How 7 Nonferrous Metals Perform at Low Temperatures

Problems encountered with steels at low temperatures have been well publicized, but what happens to other metals when temperatures drop as low as –100 F? Here are the results of tensile, fatigue and impact tests.

by T. Gela, *Stevens Institute of Technology,*
W. J. Lepkowski and H. M. Gade, *Signal Corps Engineering Laboratories*

■ Increasing use of metals at low temperatures, in both civilian and military applications, makes knowledge of the effect of temperature on the properties important. In design of parts for low temperature service the most important properties are usually strength, stiffness and ductility. Of these, strength and stiffness generally increase as the temperature is reduced but ductility may or may not be affected. Some materials retain their ductility at low temperatures; others become embrittled.

The most common method of evaluating ductility at low temperatures is to study the transition from ductile to brittle behavior. Both metallurgical and mechanical factors affect this transition.

Among metallurgical factors, composition and structure can influence the relationship. In addition, investigation of steels has shown that melting procedure, grain size and heat treatment influence the temperature at which embrittlement occurs. It is believed that such factors may affect other metals.

Structure has a pronounced effect on ductile or brittle behavior. Face-centered cubic metals such as copper and the stable austenitic steels remain ductile at low temperatures. Body-centered cubic metals such as carbon steels and hexagonal-close-packed metals like zinc generally have a transition from ductile to brittle behavior at temperatures above or below room temperature.

Mechanical design can also influence the type of failure. It is well known that sharp notches should be avoided in materials to be used at room temperature if cyclic stresses are involved. Because of the increasing tendency toward embrittlement of some materials with falling temperatures, the elimination of sharp notches is even more essential in products to be used at subzero temperatures.

Although extensive investigation has been made on various steels for low temperature service, many nonferrous materials have not been studied. Those covered in this investigation include phosphor bronze, silver solder and Nilvar, all of which have face-centered cubic structures; beryllium copper, which has a mixed structure containing both face-centered cubic and body-centered cubic phases in the commercial heat treated condition; molybdenum, tungsten and tantalum, which have body-centered cubic structures. With the exception of beryllium copper, these materials are hardenable only by cold working.

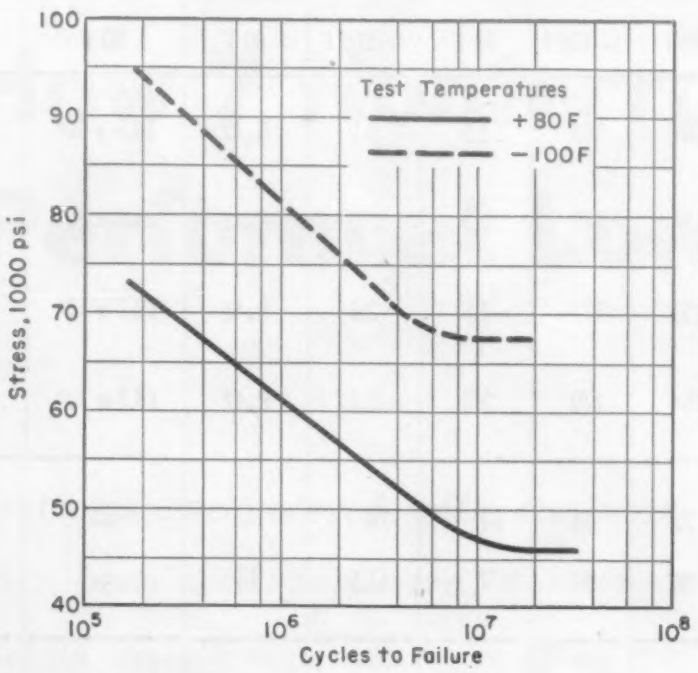
Service requirements were used as the basis for selecting the forms and conditions of the materials. For example, annealed and spring temper phosphor bronze were included to determine the effect of cold working on the properties. For molybdenum and tantalum, both sheet and wire samples were used.

Major testing was performed at 80 and —100 F, although other temperatures were used to establish trends. Tension, fatigue, Charpy impact and tension-impact determinations were made to evaluate the materials. Results are included in the tables and graphs accompanying this article. Variations in properties are discussed for each material in the following sections: The values are the results of statistical analyses of as

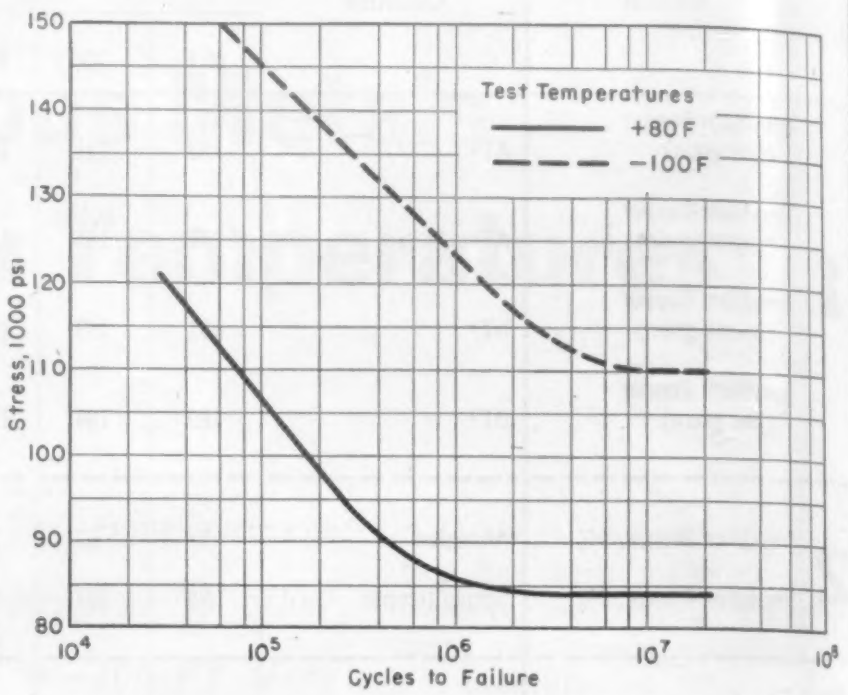
	Material	Form or Condition	Tensile Strength, 1000 psi		Yield Strength, 1000 psi 0.1% offset		Elong, % (2 in.)		Rockwell Hardness	Mod of Elast, psi	
			80 F	—100 F	80 F	—100 F	80 F	—100 F	80 F	80 F	—100 F
1	Beryllium Copper (fine grain)	AT[a]	183	191	167	168	3.5	5.0	R_e42	18.5 x 10^6	19.5 x 10^6
	Beryllium Copper (coarse grain)	AT[b]	179	184	154	149	1.3	2.8	R_e42	19.0 x 10^6	18.9 x 10^6
	Beryllium Copper (coarse grain)	HT[c]	191	199	159	177	2.6	2.6	R_e42	19.1 x 10^6	19.5 x 10^6
	Beryllium Copper (fine grain)	HT[d]	189	194	154	170	3.0	3.2	R_e42	19.1 x 10^6	19.1 x 10^6
2	Phosphor Bronze, 5%	Annealed	52	62	22	26	61	76	—	—	—
	Phosphor Bronze, 5%	Spring temper	98	107	90	97	7	11.5	—	—	—
3	Silver Solder	Annealed	65	66	44	47	35	34	—	—	—
4	Molybdenum	Sheet, partly recryst.	97	141	75[e]	130[e]	19	3.6	R_b96	48.7 x 10^6	47.5x10^6
	Molybdenum	Sheet, partly recryst. (V-notched)	100	157	—	—	1.1	0.2	—	—	—
	Molybdenum	Wire, 0.060-in., partly recryst.	121	137	89	134	17.4[f]	0	—	47.6 x 10^6	46.2 x 10^6
	Molybdenum	Wire, 0.004-in., recryst.	111	132	—	—	13.4[f]	0.9[f]	—	—	—
5	Tungsten	Wire, 0.060-in., no recryst.	214	—	196	—	2.6[f]	—	—	56 x 10^6[c]	—
	Tungsten	Wire, 0.004-in., no recryst.	320	404	—	—	1.9[f]	1.8[f]	—	—	—
6	Tantalum	Sheet, annealed	55	71	36	66	27.4	24.6	R_b81	28.2 x 10^6	28.3 x 10^6
	Tantalum	Sheet, annealed, (V-notched)	84	104	—	—	2.8	1.9	—	—	—
	Tantalum	Wire, 0.060-in., annealed	63	78	34	59	23.1[f]	21.5[f]	—	26.4 x 10^6	27.2 x 10^6
	Tantalum	Wire, 0.004-in., annealed	107	125	—	—	10.2[f]	8.8[f]	—	—	—
7	Nilvar	Sheet[g]	76	101	62	76	26.6	29.5	R_b82	21.8 x 10^6	19.7 x 10^6
	Nilvar	Sheet[g] (V-notched)	84	107	—	—	2.1	2.0	—	—	—

[a]Solution annealed at 1475 F, 30 min, water quenched, aged 700 F, 30 min, neutral salt. Average grain size, 52,000 grains per cu mm.
[b]Solution annealed at 1475 F, 2 min, resolution annealed 1475 F, 30 min, water quenched, aged 700 F, 30 min, neutral salt. Average grain size, 1500 grains per cu mm.
[c]Solution annealed at 1475 F, 30 min, water quenched, cold worked 37%, aged 700 F, 20 min, neutral salt. Average grain size, 1800 grains per cu mm.
[d]Solution annealed at 1475 F, 2 min, water quenched, cold worked 37%, aged 700 F, 20 min, neutral salt. Average grain size, 11,900 grains per cu mm.
[e]0.2% offset.
[f]In 8 in.
[g]Rolled to reduction of area of about 5%.

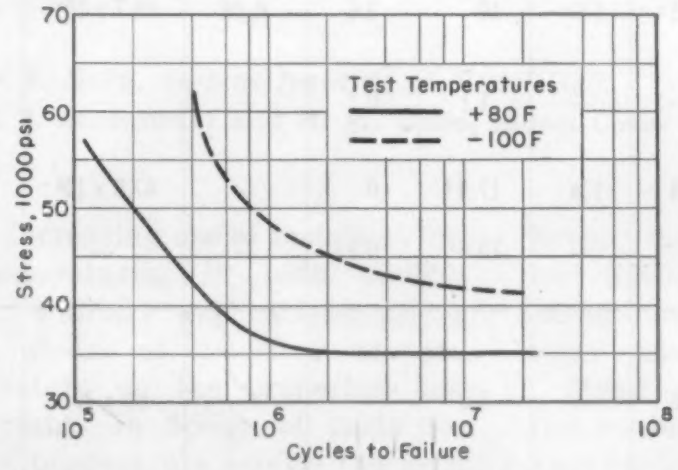
Low Temperature Fatigue Properties



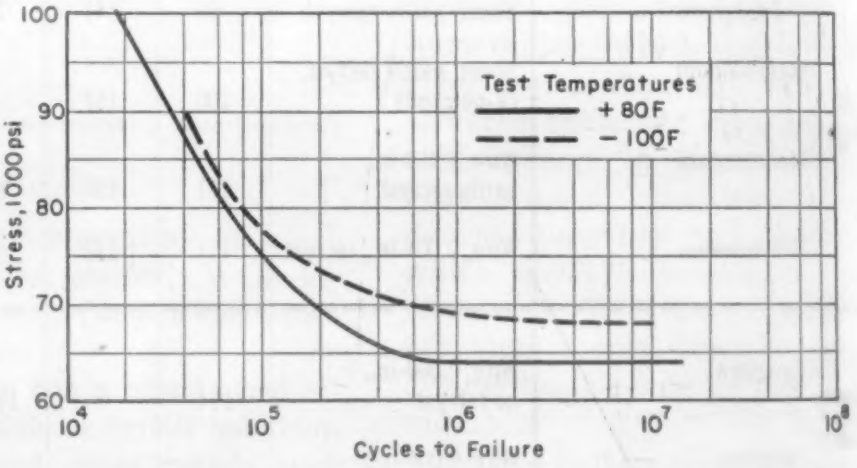
Molybdenum sheet, *0.025 in., tested longitudinal direction. Condition: stress-relief annealed.*



Molybdenum wire, *0.004 in. dia. Condition: annealed.*



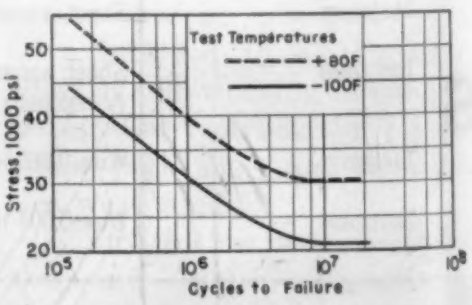
Tantalum sheet, *0.040 in., tested longitudinally. Condition: annealed 1 hr at 2550 F.*



Tantalum wire, *0.004 in. Condition: annealed for 1 hr at 2550 F.*

Material	Form or Condition	Fatigue Strength[e], 1000 psi		Endurance Ratio	
		80 F	−100 F	80 F	−100 F
Beryllium Copper	sheet AT[a]	30	33	0.16	0.14
Beryllium Copper	sheet AT[b]	25	35	0.14	0.19
Beryllium Copper	sheet HT[c]	31	37	0.16	0.19
Beryllium Copper	sheet HT[d]	31	45	0.16	0.23
Molybdenum	sheet	46	65	0.59	0.47
Molybdenum	0.004-in. wire	84	110	0.76	0.83
Tantalum	sheet	35	41	0.64	0.58
Tantalum	0.004-in. wire	64	68	0.60	0.60
Nilvar	sheet	26	30	0.33	0.30

[a], [b], [c], [d], See corresponding notes in table of mechanical properties.
[e]At 2×10^7 cycles.



Nilvar sheet, *0.040 in. Condition: rolled 1 pass hard, approximately 5% reduction in area.*

many as ten tests for each condition.

Beryllium copper

Because beryllium copper is usually used in the heat treated condition, only heat treated material was evaluated. To determine the effect of grain size and cold working, two heat treatments were employed: age hardening from the solution anneal (AT) and solution annealing, cold working and aging (HT). Heat treating conditions were varied to obtain two grain sizes in each condition. Results of tensile, fatigue and impact tests run on these materials are given in tables and graphs. These results apply only to the range of grain size investigated.

In the AT condition there is no significant increase in tensile or yield strength with falling temperature, elongation increases slightly and modulus of elasticity remains unchanged. Yield strength is significantly lower in the coarse grain than in the fine grain material, but the other properties are not affected by grain size.

In the HT condition, there is a considerable rise in yield strength with falling temperature but the other properties are not greatly changed. No variations caused by grain size are apparent.

The fatigue strengths are higher at —100 F than at 80 F under all conditions and no conclusive effects of grain size are apparent. Impact strengths are low for samples in both AT and HT condition, but there is no significant decrease in the range 200 to —96 F.

As there is no embrittlement in the range 80 to —100 F, beryllium copper should be satisfactory for use at temperatures to —100 F in any application for which it is suitable at room temperature.

Phosphor bronze

Tensile, fatigue and Charpy impact values for annealed and spring temper phosphor bronze, 5%, are shown in the tables and graphs. Tensile strength, yield strength and elongation increase slightly with falling temperatures for both conditions. There is no appreciable change in fatigue strength and no significant change in impact strength with falling temperature for the spring temper, but there is an increase for annealed material. Phosphor bronze shows ductile behavior throughout the range in both conditions and can be used to at least —100 F.

Silver solder

With falling temperatures, tensile and yield strengths increase slightly and elongation decreases. Although the scatter on the fatigue tests is quite large, it is apparent that fatigue strength increases only slightly with falling temperatures. The impact values are inconclusive but the strengths are high at all temperatures investigated and remain practically unchanged.

Because the silver solder remains tough and ductile at low temperatures, it should be useful down to at least —70 F unless it undergoes major changes resulting from alloying with the materials being joined.

Molybdenum

Previous work has shown that molybdenum is notch sensitive. Therefore tensile tests were run on both regular and V-notched sheet specimens to determine the effect of notches. The molybdenum was fabricated from a pressed and sintered compact and processed in wrought form.

Although tests were made at a series of temperatures, data are included in a table on the properties at 80 and —100 F only. In both notched and unnotched conditions, tensile strengths increase uniformly as temperature drops. However, notched material is stronger than the unnotched at all temperatures. Under both conditions, elongation drops with temperature and the notched material is quite brittle at all temperatures. Tensile strength of wire also increases with falling temperatures but ductility decreases drastically and the wires show practically no elongation at —100 F. Modulus of elasticity is unaffected by temperature. Fatigue strength increases with falling temperature.

Tension impact determinations on sheet show drastic reductions between 80 and —20 F. Wire is not affected so strongly. Data, not included in the table, obtained at other temperatures indicate a transition from ductile to brittle behavior in the range 32 to 0 F for sheet material and at about —40 F for wire.

Since molybdenum has a transformation from ductile to brittle behavior in the range under investigation, care is necessary in selecting this material for service at subzero temperatures.

Tungsten

Tensile tests on wire show that the tensile strength increases with falling temperature while the elongation is practically unchanged. The effect of wire size is apparent. Fatigue properties were determined only at room temperature. Because the tension-impact value was 0 ft-lb per sq in. at room temperature, no low temperature tests were made.

This work indicated that tungsten can be used at low temperatures only under conditions in which brittleness will not affect functioning of the part.

Tantalum

Previous work on tantalum has revealed no transition from ductile to brittle fracture down to —325 F. However, the metal has a body-centered cubic structure and there is a possibility that notches might influence the type of fracture obtained. Therefore, both notched and unnotched tensile tests were run on sheet material.

Tensile strength increases with falling temperature in both series of tests, but the strengths of the notched material are considerably higher than those of the unnotched. There is little change in elongation with temperature. However, elongation of the notched specimens is much lower than that of the unnotched. Tensile strengths of wire samples increases also with falling temperature and elongation is practically

unaffected. Like tungsten, wire size affects the strength. Temperature has practically no effect on the modulus of elasticity and little effect on the fatigue strength but the latter increases slightly. Although there is some drop in impact strength as determined by the tension-impact test, there is no indication of brittleness.

Because the mechanical properties of tantalum are not affected by temperatures down to —100 F, the material is satisfactory for service to temperatures at least that low.

Nilvar

The low temperature properties of Nilvar have not been investigated previously although this alloy is particularly interesting because of its practically constant coefficient of expansion over the range under consideration.

Results of various tests are given in the accompanying tables. Both tensile and yield strengths increase about 25% as a result of lowering the temperature to —100 F from 80 F. However, the modulus of elasticity decreases about 10%. This result is quite unusual, because most alloys show increasing modulus with falling temperatures. The endurance limit is higher at —100 F than at 80 F. Notched specimens have significantly higher tensile strengths than unnotched samples particularly at —100 F. Elongation is localized at the notches and is quite low over a 2 in. gage length.

Although the impact values obtained on both annealed and hard material drop somewhat with falling temperature, the decrease is not sufficient to indicate a change from ductile to brittle behavior to temperatures as low as —100 F.

Under tension-impact, unnotched Nilvar sheet shows an increase in strength at —100 F over the room temperature strength. Notched samples have strengths only about one-tenth those of unnotched samples; the values at —100 F are somewhat lower than those at 80 F.

These tests indicate that Nilvar can be used safely to temperatures as low as —100 F with certain precautions. Because the tensile impact data indicate that there is some notch sensitivity, care should be taken to eliminate severe notches in the design or during production when parts are made from this material.

TENSION IMPACT PROPERTIES

Material	Form	Temp, F	Impact Str, ft-lb/sq in.	Elong, % (2 in.)	Rockwell Hardness
Molybdenum	sheet	80	3450	10	R_b93
		—20	390	0	
	0.060 in. wire	80	4470	—	
		—20	3360	—	
Tungsten	0.060 in. wire	80	0	—	
Tantalum	sheet	80	2110	13	R_{15T}82
		—100	1121	4.5	
	0.060 in. wire	80	4790	—	
		—100	1300	—	
Nilvar	0.25 in. sheet	80	6010	—	R_b84
		—100	6290	—	
	0.25 in. sheet (V-notched)	80	660	—	
		—100	520	—	

CHARPY V-NOTCH IMPACT DATA

Material	Form or Condition	Rockwell Hardness	Impact Strength ft-lb	
		80 F	80 F	—100 F
Beryllium Copper	AT*	R_c 39	3.0	3.1
Beryllium Copper	HT*	R_c 40	5.4	5.5
Phosphor Bronze, 5%	annealed	—	167	193
Phosphor Bronze, 5%	spring	—	46	44
Silver Solder	annealed	—	120	138
Nilvar	annealed	R_b 76	218	162
	hard	R_b 98	97	77

*Fine grain material. See notes in table of mechanical properties.

NOMINAL COMPOSITIONS

Material	Cu	Be	Sn	Ag	Zn	Cd	Ni	Fe
Beryllium Copper	rem	2	—	—	—	—	—	—
Phosphor Bronze, 5%	rem	—	5	—	—	—	—	—
Silver Solder	15.5	—	—	50	16.5	18	—	—
Nilvar (Invar)	—	—	—	—	—	—	36	rem

Material	Impurity Content of Metals
Molybdenum	102 ppm nitrogen, 136 ppm carbon, 0.0067% oxygen
Tungsten	0.04% carbon, traces of silicon, molybdenum, copper, nickel, iron and calcium
Tantalum	0.028% carbon, 0.015% iron, 0.048% tungsten, traces of molybdenum, columbium, silica and titanium dioxide

Acknowledgment

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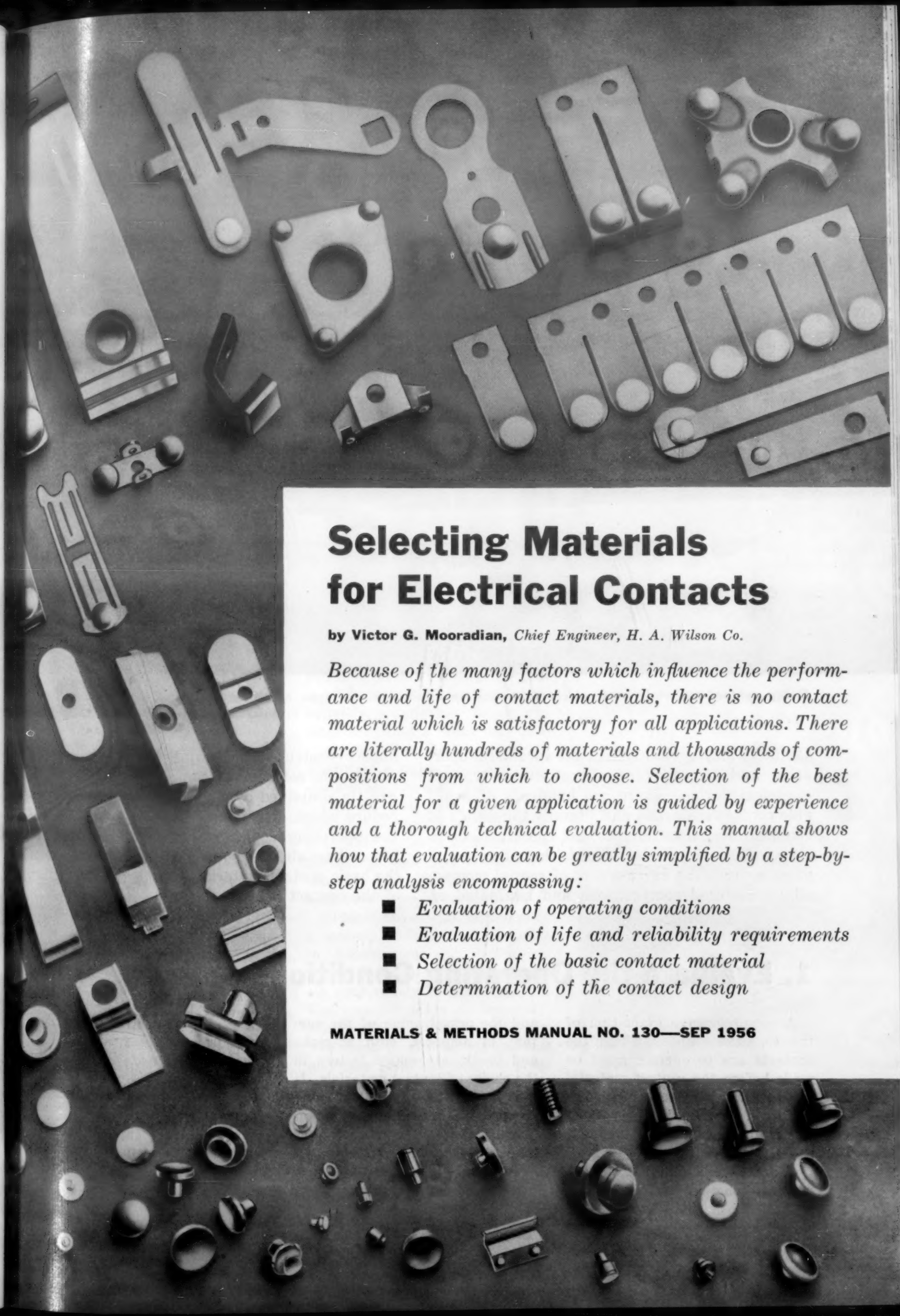


Selecting Materials for Electrical Contacts

by Victor G. Mooradian, *Chief Engineer, H. A. Wilson Co.*

Because of the many factors which influence the performance and life of contact materials, there is no contact material which is satisfactory for all applications. There are literally hundreds of materials and thousands of compositions from which to choose. Selection of the best material for a given application is guided by experience and a thorough technical evaluation. This manual shows how that evaluation can be greatly simplified by a step-by-step analysis encompassing:

- *Evaluation of operating conditions*
- *Evaluation of life and reliability requirements*
- *Selection of the basic contact material*
- *Determination of the contact design*

MATERIALS & METHODS MANUAL NO. 130—SEP 1956

Westinghouse Electric Corp.

***Relay** contact materials vary widely depending on application and type of service.*

Contacts play a vital role in the successful operation and longevity of almost every type of electrical device. There are hundreds of available contact materials and literally thousands of compositions, sizes, shapes and constructions to choose from. In the last decade there has been a great spurt in the development of special purpose alloys, sintered compositions and laminated or duplex constructions. Despite this apparent complexity, the selection of contact materials can be greatly simplified by a careful step-by-step procedure which encompasses: 1) an evaluation of the operating conditions, 2) an evaluation of life and reliability requirements, 3) selection of the basic contact material, and 4) determination of the contact design.

1. Evaluate the Operating Conditions

A comprehensive evaluation of the conditions under which the contacts are to operate must be made before the contact material can be selected. Operating conditions can be classified broadly as electrical, mechanical or ambient.

Electrical conditions

Current—The nature of the current—whether a.c. or d.c.—and the actual value of the current in amperes, both at make and break, are major factors in the choice of contact materials. It is important to note that in many circuits the transient or instantaneous current is much higher than the normal current. In motors and incandescent lamps, for example, the current inrush on closing may be 5 to 20 times the normal current, and contacts must be designed with sufficient current-carrying capacity to avoid sticking or welding when contact is made.

1. Light duty applications—below 1.5 to 2.0 amp. Currents of this magnitude are generally encountered in instruments and

small relays and do not present any special design problems. Suitable contact materials include silver and platinum alloys, tungsten and sintered metal powders.

2. Medium duty applications—2 to 5 amp. Silver and platinum alloys, tungsten and sintered metal powders are also suitable in this range. In view of the low conductivity of platinum alloys and tungsten, however, care must be taken so that the size and design of the contacts provide sufficient current carrying capacity.

3. Heavy duty applications—5 to 20 amp. This current range is generally too high for platinum alloys and tungsten. A silver alloy or a sintered metal powder is generally used.

4. Extra heavy duty applications—above 20 amp. A sintered metal powder must generally be used in this range.

Voltage—High contact opening speeds and presence of inductance in a circuit may result in induced peak voltages on break that are considerably above normal. All materials possess a characteristic minimum arcing voltage in the 10 to 20 v range. If the maximum voltage is below this value, arcing will not occur. Above this voltage arcing and loss of contact material due to arc erosion must be expected.

Overload requirements — Contacts must often be designed with sufficient current carrying capacity to meet specific overload requirements as well as the running current encountered in normal duty.

Auxiliary protection—Frequently protective devices (arc suppressors) such as capacitor or resistor circuits or blowout coils will decrease the burden on contacts on break by reducing arcing. At the same time, however, because of the higher current inrush on make they may promote contact sticking or welding. Consequently, consideration must be given to whether the contacts have a sufficient safety margin on either make or break to benefit from the protective circuit. The best protective circuit is usually determined through actual tests.

Mechanical conditions

Frequency of operation — The number of makes and breaks per unit time determines the service life of a pair of contacts. At high frequencies special factors such as heat dissipation and high local temperatures must be accounted for. In some devices, such as signals and limit controls, contacts operate only occasionally. In other devices, such as high speed cams and vibrators, contacts operate many thousands of times per minute. For the purpose of taking into account the amount of energy that must be dissipated in the form of heat and arc erosion, it is convenient to classify all applications by their frequency of operation as follows:

1. Low frequency—up to 1 per min.

2. Intermediate frequency — 1 per min to 10 per sec.

3. High frequency—more than 10 per sec.

Speed of operation—In d.c. circuits a slow rate of speed usually produces greater arcing, so that a quick make and break ("snap-action") is desirable. In a.c. circuits too rapid a break may produce excessive induced voltage. Therefore, a quick make and moderate break are desirable.

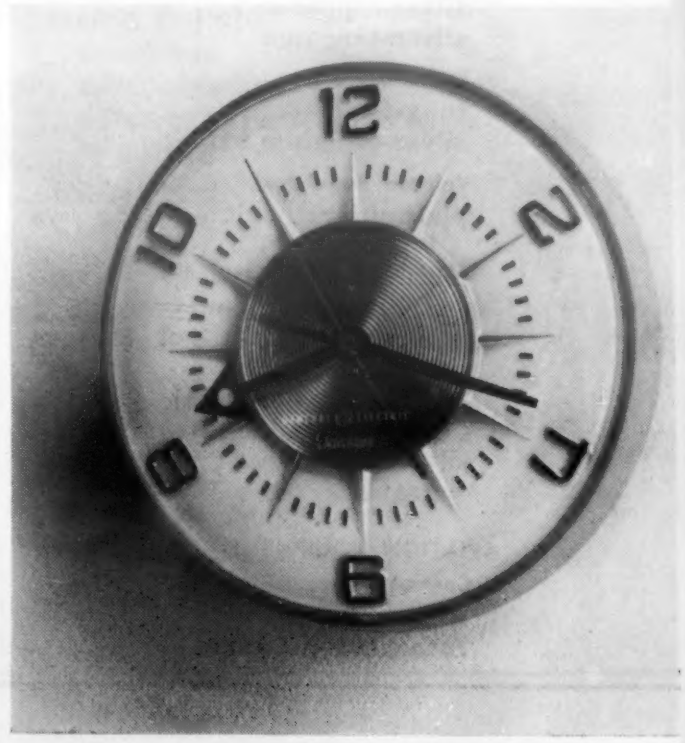
Contact gap—Gap should be sufficient to prevent sustained arcing. This factor is especially important in inductive circuits because of high induced peak voltages across the contacts.

Contact force—The hardness of a material affects its resistance to deformation and mechanical wear. Because contact materials vary widely in hardness, contact pressure plays an important role in the selection of materials. The force in various applications may vary from less than one gram to several pounds. The force available for making a circuit may be quite different from that available for breaking the circuit. In general, the contact pressure on the make should be the maximum that the material will withstand without excessive deformation and mechanical wear.

Wiping, sliding or rolling — Some form of motion between contacts is often desirable to break down oxides or chemical films that may be formed. In certain cases, however, this same motion may produce mechanical interlocking or excessive wear of the contact material.

Open contacts—Contacts must operate reliably after remaining open for lengthy time periods. Open contacts are particularly susceptible to adverse environments, and materials must be capable of withstanding oxidation, corrosion or other chemical attack during extended idleness.

Method of operation — The method of contact operation — whether it be mechanical (by cam), electrical (by coil and armature), thermostatic (by bimetal), or manual (by push button or lever)—often affects the choice of material. The method of contact operation should be made as favorable to the contacts as possible. If at all practical, contacts should be allowed to operate in a vertical



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Clock *contacts are selected for low and uniform contact resistance and resistance to oxidation and film formation. Materials most commonly used are: platinum-irridium, palladium-silver-nickel, palladium-silver and tungsten.*

Contact Materials Used

ARCING TIPS
- silver-tungsten
- copper-tungsten
- silver-molybdenum
- silver-tungsten carbide
- silver-cadmium oxide

AUTOMOTIVE EQUIPMENT

Circuit Breakers
- silver-cadmium
- silver-copper-nickel
- silver-nickel
- silver-tungsten

Directional Signals
- silver-cadmium
- silver-nickel

Distributors
- tungsten

Gasoline and Oil Gages
- platinum-ruthenium
- silver-iron
- silver-cadmium (+) vs silver-palladium (–)
- silver-palladium (+) vs tungsten (–)

Generator Cut-Outs
- silver-copper-nickel
- silver-palladium

Horn Relays
- silver-copper-nickel

Horns
- silver-copper-nickel

Light Switches
- fine silver
- silver-copper-nickel
- silver-tungsten

Radio Vibrators
- tungsten
- silver-cadmium oxide

Voltage Regulators
- platinum-ruthenium (+) vs tungsten (–)
- platinum-palladium-ruthenium (+) vs tungsten (–)
- palladium-silver-nickel (+) vs tungsten (–)
- silver-cadmium-nickel (+) vs silver-palladium (–)
- silver-manganese (+) vs silver-graphite (–)

AVIATION EQUIPMENT

Control Relays
- tungsten
- ruthenium-platinum

Relays (Light Duty)
- fine silver
- silver-copper-nickel
- silver-cadmium

Relays (Medium Duty)
- silver-cadmium
- silver-copper-nickel
- silver-cadmium oxide
- silver-iron

Relays (Heavy Duty)
- silver-cadmium oxide
- silver-tungsten
- silver-tungsten carbide

Switches (Light Duty)
- fine silver
- silver-copper-nickel
- silver-iron

Switches (Heavy Duty)
- silver-cadmium oxide
- silver-tungsten
- silver-tungsten carbide

BLANKETS
- platinum-iridium
- palladium-ruthenium

BUSINESS MACHINES
- tungsten
- platinum-iridium
- silver-tungsten
- silver-tungsten carbide

CIRCUIT BREAKERS

In Air
- silver-tungsten
- silver-molybdenum
- silver-tungsten carbide
- silver-cadmium oxide

In Oil
- copper-tungsten
- copper-tungsten carbide

CLOCKS
- platinum-iridium
- palladium-silver-nickel
- palladium-silver
- tungsten

COIN OPERATED DEVICES
- coin silver
- silver-copper-nickel
- tungsten

ELECTROMAGNETIC COUNTERS
- fine silver
- silver-copper-nickel
- silver-platinum

ELEVATOR CONTROLS
- silver-graphite
- silver-tungsten
- silver-tungsten carbide

FIRE ALARMS
- platinum-iridium
- platinum-ruthenium
- palladium-ruthenium

FLUORESCENT LAMP CONTROLS
- fine silver
- silver-copper-nickel
- silver-palladium

HEATING PADS
- platinum-iridium
- palladium-ruthenium
- palladium-silver-nickel

HORNS AND HORN RELAYS

Automobile—see automotive equipment

Industrial
- tungsten

Railway
- tungsten
- silver-copper-nickel

HOUSEHOLD EQUIPMENT

Circuit Breakers
- silver-tungsten
- silver-molybdenum

Wall Switches
- fine silver
- silver-copper-nickel
- silver-iron
- silver-cadmium oxide

Thermostats, Heating
- platinum-iridium
- platinum-ruthenium
- palladium-silver-nickel
- gold-silver-platinum

INDUCTION FURNACE SPARK GAPS
- tungsten
- platinum-iridium

INSTRUMENTS
- platinum-ruthenium
- platinum-iridium

IRONS
- fine silver
- silver-palladium

plane to minimize dirt accumulation.

Chatter or bounce—The effect of chatter during break and of bounce during make is to force the contacts to make and break several times per operation instead of just once. These effects tend to decrease contact life substantially. To find out if contacts are making and breaking cleanly, it is often necessary to observe their operation with an oscillograph. Changes in contact design i.e., size, mass, spring material, etc., are usually necessary to eliminate chatter or bounce.

Ambient conditions

Gases or fumes—The presence of gases or fumes has an appreci-

for Specific Applications—*Listed in order of their predominance*

MAGNETOS
- Automotive
  - tungsten
  - platinum-ruthenium
  - platinum-iridium
- Aviation
  - platinum-iridium
  - platinum-ruthenium
  - tungsten
- Marine
  - platinum-ruthenium
  - platinum-iridium
  - tungsten
- Tractors
  - tungsten

MERCURY SWITCHES
- molybdenum

MOTORS
- Protective Devices
  - fine silver
  - silver-palladium
  - silver-platinum
  - silver-cadmium oxide
- Speed Governors
  - tungsten
  - platinum-ruthenium
  - platinum-iridium
- Starters
  - silver-cadmium
  - silver-cadmium oxide
  - silver-tungsten
- Starting Windings
  - silver-copper-nickel
  - silver-cadmium

POTENTIOMETER SLIDING CONTACTORS
- platinum-ruthenium
- palladium-silver-nickel
- gold-silver-platinum

PYROMETERS
- platinum-iridium

RADIOS
- Automatic Tuners
  - silver-copper-nickel
  - silver-platinum
  - coin silver
- Band Switches
  - silver-copper-nickel
  - silver-zinc
  - silver-graphite
- Vibrators, Power Packs
  - tungsten
  - silver-tungsten

RAILWAY SIGNALS
- platinum-ruthenium
- palladium-silver-nickel

RANGES
- fine silver
- silver-palladium
- silver-cadmium oxide

RAZORS
- tungsten
- platinum-iridium

RECTIFIERS
- silver-tungsten

REFRIGERATORS
- Overload Switches
  - silver-cadmium
  - silver-palladium
  - silver-cadmium oxide
- Thermostats
  - fine silver
  - silver-cadmium
  - silver-palladium

ROASTERS
- fine silver
- silver-palladium
- silver-cadmium oxide

SLIDING CONTACTORS
- silver-graphite

LIGHTING CONTROLS
- platinum-ruthenium
- silver-copper-nickel
- silver-cadmium oxide

TAP CHANGERS
- Current
  - silver-copper-nickel
  - silver-tungsten
- Transformer
  - silver-tungsten
  - copper-tungsten

TELEGRAPH RELAYS
- tungsten
- platinum-iridium

TELEPHONE EQUIPMENT
- Dials
  - silver-palladium
  - palladium
- Jacks
  - palladium-silver
  - silver-zinc
- Relays
  - palladium-silver
  - gold-silver
  - palladium
- Voice Relays
  - palladium-silver
  - palladium-ruthenium
  - palladium-iridium

TELETYPE MACHINES
- tungsten
- molybdenum

TELEVISION CONTROLS
- silver-copper-nickel
- silver-palladium
- silver-cadmium
- silver-tungsten

THERMAL CUT-OUTS
- silver-copper-nickel
- silver-cadmium
- silver-cadmium oxide

THERMOSTATS
- fine silver
- silver-platinum
- platinum-ruthenium
- platinum-iridium
- palladium-silver-nickel

TIME DELAY CONTROLS
- silver-cadmium
- silver-copper-nickel
- silver-cadmium oxide

TOASTERS
- fine silver
- silver-palladium

TRAFFIC SIGNALS
- silver-iron
- silver-cadmium
- silver-copper-nickel
- silver-cadmium oxide

VOLTAGE REGULATORS
- Automotive—see automotive equipment
- Industrial
  - platinum-ruthenium
  - platinum-iridium
  - tungsten

WATER HEATERS
- fine silver
- silver-platinum

WELDING MACHINES
- tungsten
- silver-tungsten

able effect on contact operation. Sulfur fumes, for example, are especially detrimental to silver and many silver alloy contacts because of the increased contact resistance of silver sulfide films. For such applications, the more corrosion resistant platinum alloys should be used. The presence of hydrocarbons such as gasoline and oil is detrimental to the operation of some platinum alloy contacts. Catalytic action forms a finely divided black coating which may eventually insulate the contacts completely.

Foreign materials—The presence of dirt, dust or grit may increase arcing across contacts and lead to excessive temperature rise or localized pitting of contact sur-

faces. In severe cases these impurities may produce an open circuit.

Special atmospheres—Sealing of contacts in a special inert or reducing atmosphere is often beneficial, particularly when oxidation must be prevented. Use of these atmospheres must be carefully considered, however, as they sometimes produce increased arc erosion.

Temperature and humidity—Contact materials selected for use at elevated temperatures must be capable of withstanding accelerated oxidation and chemical reactions. Also, materials used in excessively humid environments should be capable of withstanding abnormal oxidation and corrosion attack.

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***Blanket** contacts are commonly made from alloys of platinum-iridium and palladium-ruthenium for extra hardness and wear resistance.*

2. Evaluate the Life and Reliability Requirements

Contact resistance

Contact resistance has an important effect on the life and reliability of electrical contacts. Build-up of resistance during operation may cause an increase in temperature, which in turn may accelerate oxidation or film formation to the point where an open circuit is created. Essentially, the over-all contact resistance of a pair of contacts is dependent on three factors:

Bulk resistance—Bulk or volume resistance is calculated by multiplying the specific resistance (resistivity) of a contact by its depth and dividing by its area. Specific resistance is a function of material composition and determines whether a contact material can carry a given current without destructive overheating.

An alloy always possesses a higher resistivity than any of its component elements. Thus, a copper-silver alloy has a higher resistivity than either copper or silver. The resistivity of platinum or palladium, which is higher than that of silver, is increased even further when silver is added.

Constriction resistance—Constriction resistance is the resistance across the interface or the area where two mating contacts touch. This resistance can be reduced by increasing the force between the contacts, by decreasing the hardness of the material and by using a contact configuration with a larger contact area. The constriction resistance of a pair of contacts usually varies from 3 to 20 times the value of volume resistance.

Film resistance—The presence of semi- or nonconducting particles on contact surfaces causes film resistance. Chemical films may be formed by oxidation, corrosion or other reactions between the contact material and surrounding media. Mechanical films may be formed by dust, oil or other foreign materials.

Arc erosion

Although it is difficult to explain the mechanism of material loss due to the arcing that takes place when a pair of contacts makes or breaks a circuit, it is apparent that there are two basic phenomena: sputtering at the cathode, which is an actual thermionic disintegration of the material; and vaporization of material at the anode.

One of three processes may initiate an arc: 1) a spark or electrical discharge that occurs when a critical voltage is exceeded (usually 300 to 350 v for most contact materials in air); 2) a glow discharge or luminous breakdown of the air between contacts that occurs below the sparking voltage if sufficient ionization has taken place; or 3) separation of two contacts after an electric circuit has been completed. In the separations of contacts, the current reaches sufficient density to actually melt and vaporize the final small point of contact. This metal vapor discharge can change into an arc if sufficient energy is available in the circuit.

During contact operation the anode reaches a higher temperature than the cathode (Thomson effect). When an arc occurs between two contacts, the anode operates at the boiling point of the metal and causes material loss

by vaporization. The characteristics of arc erosion vary for different contact materials (depending principally on the melting and boiling points), but the rate of arc erosion for a given material is proportional to the circuit current and to the frequency and number of operations.

Material transfer

The type and amount of deposit of material from one contact to another affects both the life and reliability of contacts. In a.c. circuits, metal transfer does not have a definite direction unless one contact is operating at a higher temperature than the other; in this case transfer is in the direction of the cooler contact.

In d.c. circuits the transfer may be negative (from anode to cathode) or positive (from cathode to anode), depending on the current and voltage conditions. Negative or bridge transfer, in the form of a long thin peak and crater, occurs when current and voltage are below the characteristic minimum values for a particular material. Minimum arcing voltages and currents for various materials are listed in Tables 1 and 2. At currents and voltages above these values positive transfer, in the form of a larger mound over a larger area, takes place. The greater the arc energy, the greater the positive transfer.

Values in Table 1 represent the highest current at different voltages that theoretically can be interrupted without arc formation.

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Toaster *contacts are usually made from fine silver or* ***silver-palladium.***

In practice, these values will be increased by the presence of excessive humidity and reduced by sharp projections, surface roughness and/or the presence of oxides on contact surfaces.

Values in Table 2 represent the lowest voltage at which an arc will form at atmospheric pressure. Theoretically, at voltages below these values a current of any magnitude may be interrupted without arcing and there will generally be negative material transfer. Above these voltages arcing will occur with positive transfer, the amount of transfer being related to arc intensity and duration. In practice, minimum voltages may be considerably affected by surface heating due to contact resistance; circuit impedance; cooling and heat dissipation through the contacts; and cleanliness and smoothness of surfaces.

When a contact material is used at or close to its minimum arcing current and voltage, there is some slight arcing of short and unstable duration. Under these conditions there is an approximate equilibrium between positive and negative transfer, and contacts will operate for long periods with little or no apparent material transfer or arc erosion. Because

TABLE 1—MINIMUM ARCING AMPERAGE FOR COMMON CONTACT MATERIALS

Material \ Line Voltage	24 v	50 v	110 v	220 v
Silver	1.5	1.0	0.5	0.5
Gold	1.7	1.5	0.5	0.5
Platinum	4.0	2.0	1.0	0.5
Palladium	3.5	1.5	1.0	0.5
Tungsten	12.5	4.0	2.0	1.5
Molybdenum	10.0	3.0	1.5	1.0
Nickel	—	1.5	1.0	0.5
Copper	—	2.0	0.5	0.5
Cadmium	0.5	0.5	0.5	0.5
Zinc	0.5	0.5	0.5	0.5
Iron	—	1.5	1.0	0.5

TABLE 2—MINIMUM ARCING VOLTAGE FOR COMMON CONTACT MATERIALS

Silver	12
Gold	15
Platinum	16
Palladium	15
Tungsten	17
Molybdenum	17
Nickel	14
Copper	12
Cadmium	10
Zinc	11
Iron	12-15
Graphite	18-22

these ideal operating conditions are not often encountered, it is usually necessary to select contact materials and designs that function satisfactorily despite substantial negative or positive metal transfer.

Sticking or welding

Sticking or welding of a pair of contacts normally occurs by one of three processes: 1) mechanical interlocking caused by excessive metal transfer; 2) butt welding on contact make due to the formation of molten bridges that freeze between the contacts as the surfaces come together; and 3) formation of an arc weld from molten bridges on contact break.

If excessive transfer occurs, any wiping or sliding action between the contacts is undesirable and will only tend to increase sticking. The most important single factor in the prevention of butt or arc welds is the proper selection of contact materials. Materials with high melting and boiling points and high electrical and thermal conductivity tend to keep surface contact temperatures at a minimum. Materials with high corrosion resistance prevent the formation of chemical films and tarnish, and materials that either contain or can form oxides decrease the surface wettability of contacts. Methods for decreasing sticking and welding are outlined in the accompanying box.

Energy dissipation

Electrical energy at the contacts is dissipated almost entirely as heat energy, less than 1% occurring as light energy in visible arcing. For this reason the ability to dissipate heat by radiation or conduction is an important factor in determining contact performance and reliability. Most of the heat loss in closed contacts is due to the I^2R effect of the constriction resistance. Only minor heat loss is due to the I^2R effect of the specific resistance of the contact material itself. Therefore, it is important to keep constriction resistance as low as possible by designing for maximum contact pressure and proper configuration and hardness.

During operation, the temperature of contacts rises until they reach a state of equilibrium where the heat loss due to radiation and conduction is equal to the heat input from construction resistance and arc energy. Arc erosion and the tendency to stick or weld are in direct proportion to the amount of energy that must be dissipated at and through the contacts. To minimize this energy, the equilibrium temperature must be kept as low as possible by selecting the optimum contact material and design.

How to Reduce Energy Dissipation

To reduce heat caused by constriction resistance:

1. Use contact material with maximum electrical and thermal conductivity
2. Provide optimum contact pressure
3. Use material with optimum combination of hardness, ductility and strength
4. Use optimum contact configuration
5. Minimize oxide or film formation
6. Use contact backing member with maximum electrical and thermal conductivity

To reduce arc energy:

1. Use contact material with highest melting and boiling point
2. Minimize oxide formation
3. Use optimum speed of contact break
4. Decrease circuit inductance
5. Use auxiliary protective circuit (capacitance and/or resistance) across contacts

Eight Ways to Reduce Sticking of Contacts

1. Use contact materials with high melting and boiling point, high electrical and thermal conductivity, and good resistance to tarnish films
2. Use materials that will provide an oxide or other constitutent to decrease contact wettability
3. Provide maximum opening force to break minute welds
4. Provide high closing force to prevent excessive I^2R heating
5. Use optimum speed of make and break
6. Prevent contact bounce on make and contact chatter on break
7. Prevent short arcs on make
8. Decrease arcing on break with auxiliary protection across contacts

PROPERTIES OF THE FOUR MAJOR CONTACT GROUPS

Silver and basically silver alloys	Highest electrical and thermal conductivity. Lowest contact resistance.
Platinum metals and their alloys	Highest resistance to oxidation and corrosion. Maximum sureness of operation. High hardness and strength.
Tungsten and molybdenum	Highest resistance to arc erosion and metal transfer. High resistance to sticking and welding. Highest hardness.
Sintered metal powders	High electrical and thermal conductivity. High resistance to arc erosion, metal transfer, sticking and welding. High hardness and strength.

PROPERTIES AND APPLICATIONS OF COMMON CONTACT MATERIALS

Material	Advantages	Disadvantages	Typical Applications
SILVER AND ITS ALLOYS			
Fine Silver	High conductivity[a], low contact resistance (5 to 10 gm force required), good resistance to oxidation and corrosion[a], low cost	Low melting point[a], low hardness[a]	Most common contact material. Light duty, light pressure devices and intermittent operation in medium and heavy duty devices. Thermostats, household appliances, pressure switches, motor starters, telephone relays, voltage regulators, circuit breakers
Silver-Copper Alloys (including coin silver, sterling, etc.)	Conductivity slightly lower than fine silver. Higher hardness, less material transfer and sticking or welding	Higher contact resistance than fine silver (10 to 20 gm force required). More susceptible to oxidation and film formation[a]	Light and medium duty devices with moderate operating frequency. Thermostats, pressure switches, relays, generator cut-outs, voltage regulators, starting relays, household and automotive lighting switches
Silver-Copper-Nickel Alloys	Less susceptible to oxidation and film formation, harder, and more resistant to sticking or welding, than binary silver-copper alloys. Low material transfer	Lower conductivity higher contact resistance (30 to 50 gm force required)	Heavier duty devices. Horn relays, generator cut-outs, light switches, overload circuit breakers, thermostats, pressure switches, starting switches, industrial signals, motor-starting relays
Silver-Cadmium and Silver-Copper-Cadmium Alloys	Medium conductivity, good hardness, low contact resistance, good arc quenching qualities[a], low material transfer	Limited current carrying capacity, low melting point	Low contact pressure and low inertia applications. Meter and gaging devices, automotive gas and oil gages, over-load relays, sensitive low current relays, polarized circuit breakers. Infrequent operation in a.c. contactors and starters, motor overload relays, industrial control relays, thermal overload switches
Silver-Zinc Alloys	Medium conductivity, low and uniform contact resistance, high resistance to corrosion and film formation, low material transfer	Limited current carrying capacity, low melting point	Low current devices such as thermostats and relays. Special instruments requiring resistance to tarnishing and film formation
Silver-Base Alloys Containing Gold, Platinum and/or Palladium	Medium conductivity, very low and uniform contact resistance. Higher hardness, melting point, resistance to oxidation and film formation, and resistance to sticking or welding than fine silver or silver-base alloys	Limited current carrying capacity. Susceptible to wear and pitting under certain conditions	Low voltage, low current, light contact pressure devices including telephone relays and dials, telegraph keys, railway-signal relays. Also, sensitive pressure switches and gages and automotive signaling devices
PLATINUM METALS AND THEIR ALLOYS			
Platinum	Low and uniform contact resistance, high oxidation and corrosion resistance, high melting point, good resistance to arc erosion	Low conductivity, low hardness	Devices using light contact pressure and low voltage and current that must combine low operating frequency with maximum sureness of operation. Telephone relays, fire alarms, signal devices, heating pad thermostats, sensitive instruments. Applications involving high ambient temperature or industrial corrosive atmospheres

3. Select the Basic Contact Material

Selection of the basic contact composition can be made only after operating conditions and service life and performance requirements have been thoroughly evaluated. All contact materials fall into one of four major groups, each of which has certain unique

Table continues on next page, text on p 132.

PROPERTIES AND APPLICATIONS OF COMMON CONTACT MATERIALS—Continued

Material	Advantages	Disadvantages	Typical Applications
PLATINUM METALS AND THEIR ALLOYS—Continued			
Platinum Alloys (including alloys with iridium, ruthenium, iridium-osmium, palladium, ruthenium)	Harder than platinum. Low and uniform contact resistance. High resistance to oxidation, film formation and arc erosion	Lower conductivity than platinum. Requires higher contact pressure, tends to stick under some conditions	Replace platinum when hardness and resistance to wear and corrosion are required in magnetos, voltage regulators, telephone relays, recorders, heating pads and all types of sensitive equipment. Used in high frequency, high pressure devices where current is not too high (vibrators and motor governors). Also used as positive contact against negative tungsten contact in d.c. polarized circuits for maximum resistance to arc erosion and material transfer (voltage regulators and vibrating devices)
Palladium	Low contact resistance, good oxidation and corrosion resistance, fairly high melting point, good resistance to arc erosion	Low conductivity, low hardness	Replaces platinum in less critical applications where sensitive response is required on low current, low voltage duty
Palladium Alloys (including alloys with ruthenium silver-nickel)	Low contact resistance, higher hardness than palladium. Good resistance to arc erosion and material transfer and to sticking or welding	Lower conductivity, lower melting point and higher contact resistance than palladium	Replace palladium in sensitive applications where greater hardness is required. Used as positive contact against negative tungsten (or other platinum group metal) contact in d.c. polarized circuits
TUNGSTEN AND MOLYBDENUM			
Tungsten	High hardness. Excellent resistance to arc erosion and to sticking or welding	Medium conductivity, high contact resistance. Susceptible to oxidation	Low current, high frequency devices where minimum contact force of 100 gm is available. Auto ignitions, vibrators, electric razors, business machines, voltage regulators, motor speed governors, aviation and marine magnetos, aviation relays, Diesel starting equipment
Molybdenum	Similar to tungsten in resistance to mechanical wear and to sticking or welding. More ductile[a], and more resistant to atmospheric corrosion and certain chemical actions	Similar to tungsten	Can replace tungsten (except above 50 v) in vibrators, special thermostats, automatic card sorters, business machines, communication relays, flashers, mercury switches
HIGH CONDUCTIVITY-REFRACTORY MATERIALS			
Copper-Tungsten	High conductivity, hardness and resistance to arc erosion and sticking or welding	High contact resistance, fair to poor current carrying capacity	High current, heavy duty switches and relays, air and oil circuit breakers, oil-immersed contactors and transformer tap changers, drum controllers
Silver-Tungsten	High conductivity, hardness and resistance to arc erosion and sticking or welding. Good wearing qualities, excellent current carrying and current interrupting qualities. Can carry heavy current with light or medium contact pressure	High contact resistance (but lower than that of copper-tungsten), low ductility	Heavy duty switches, relays, contactors. Current carrying and current interrupting contacts and arcing tips in light and medium duty air circuit breakers

PROPERTIES AND APPLICATIONS OF COMMON CONTACT MATERIALS—Concluded

Material	Advantages	Disadvantages	Typical Applications
HIGH CONDUCTIVITY-REFRACTORY MATERIALS—Continued			
Silver-Molybdenum	High conductivity, hardness and resistance to arc erosion and sticking or welding. Good wearing qualities. Greater ductility and greater resistance to oxide film formation than silver-tungsten	High contact resistance (but lower than that of silver-tungsten). Somewhat lower resistance to arc erosion and sticking or welding than silver-tungsten	Heavy duty switches, relays, contactors. Current carrying and current interrupting contacts in light duty air circuit breakers. Arcing tips and intermediate contacts in heavy duty air circuit breakers
Silver plus Carbides of Tungsten or Molybdenum	High conductivity, high resistance to arc erosion and to sticking or welding. Higher hardness than silver-tungsten or silver-molybdenum. Resists oxidation and film formation	Lower ductility (because of high hardness) than silver-tungsten or silver-molybdenum	Special heavy duty switches, relays and contactors where lighter contact pressures are encountered. Arcing tips in special heavy duty air circuit breakers. Sometimes replaces silver-tungsten or silver-molybdenum in special high current applications when lower contact resistance is required. Sometimes used against silver-semirefractory contacts for better wear and greater resistance to arc erosion
HIGH CONDUCTIVITY-SEMI REFRACTORY MATERIALS			
Silver-Nickel	High conductivity, fair resistance to arc erosion and metal transfer, good wearing qualities, excellent strength and ductility	Higher contact resistance than fine silver or silver alloys	Replaces fine silver or silver alloys in light and medium duty applications where higher current rating and greater freedom from sticking or welding is required and where use of standard silver-refractory materials is not warranted. Motor starters and controllers, special heavy duty relays
Silver-Graphite	High conductivity, excellent wear and lubricating properties, good resistance to arc erosion. Contact resistance as low and uniform as that of fine silver	Low ductility. More metal transfer than fine silver under certain conditions	Used mainly in sliding contacts because of its excellent lubricating qualities. Brushes and sliding contactors in slip rings, commutators and similar devices. Also used as intermediate current carrying contacts in air circuit breakers where standard silver-refractory materials are used for arcing tips
Silver-Iron	High conductivity. Good resistance to sticking or welding, especially with high inrush currents. Excellent strength and ductility	Higher contact resistance than fine silver due to oxide film formation. Unsuitable for high ambient temperatures or corrosive atmospheres	Replaces silver or silver alloys when better resistance to sticking or welding on high inrush currents is needed in resistive and incandescent lamp loads. Household switches, light duty motor starters and controllers, special heavy duty relays
Silver-Cadmium Oxide	High conductivity, excellent resistance to arc erosion and to sticking or welding, low and constant contact resistance. High current carrying capacity with low temperature rise, good strength and ductility, good arc quenching characteristics	Resistance to film formation (sulfides) about the same as fine silver	Replaces fine silver and silver alloys when higher current carrying capacity, greater resistance to sticking or welding, or lower temperature rise is required, and where use of standard silver-refractory materials is not warranted. Aircraft circuit breakers and relays, motor contactors and starters, industrial controls and relays, limit switches, air circuit breakers, current carrying contacts for multi-stage circuit breakers

Significance of terms:

Conductivity—Both electrical and thermal; affects current carrying capacity.

Contact resistance—Affects contact force required.

Melting point—Affects tendency to stick or weld, material transfer and arc erosion.

Hardness—Affects ability to withstand mechanical wear, impact, high contact pressure and high speed of operation.

Arc quenching qualities—Affect arc erosion.

Ductility—Affects ability to withstand excessive contact forces without cracking.

Oxidation and corrosion resistance—Affects contact resistance and temperature rise.

Film formation—Affects contact resistance and temperature rise.

Western Electric Co.

Teletypewriter and office typewriter *contacts of tungsten and molybdenum operate at low currents and high mechanical frequencies. Contacts must possess high hardness and resistance to wear, sticking and welding.*

International Business Machines Corp.

properties. Details on properties, advantages, disadvantages and applications are given in the accompanying charts.

Silver and silver alloys

Silver possesses the highest electrical and thermal conductivity of all contact materials and is easily fabricated into a great number of shapes. Although silver is subject to oxidation, the oxides decompose and revert back to pure silver at the relatively low temperatures incurred during arcing. Thus, low surface contact resistance is maintained over long periods.

The principal disadvantages of silver are its low melting point, its relatively low hardness, its tendency to form sulfide films, and its tendency to build up from one electrode to another when currents become excessive. These disadvantages can be eliminated or mitigated to a large extent by the addition of alloying elements such as copper, cadmium, nickel, zinc, manganese, platinum, palladium, iron and others.

Platinum metals and alloys

Platinum, palladium, gold and their various alloys resist oxidation caused by high local temperatures during arcing, and are capable of maintaining low contact resistance over long periods. Because of the low hardness of the pure metals, alloys are commonly used to provide higher physical properties without undue sacrifice of surface properties. The principal alloying elements used are other metals of the platinum group, such as iridium, ruthenium, osmium and rhodium. Copper, nickel and iron are also used. Silver is the principal alloying element for platinum, palladium and gold in many applications.

Tungsten and molybdenum

The melting point of tungsten (6098 F) is the highest of any of the metallic electrical conductors. Tungsten is capable of withstanding arcing temperatures that would melt and boil away other less refractory metals during the making and breaking of a circuit. It also possesses excellent resis-

tance to sticking or welding.

Tungsten is limited to some extent because of its susceptibility to oxide formation. The high resistance and poor conductivity of tungsten oxides is often the cause of an open-circuit condition. To overcome this difficulty, a high closing force (100 to 200 gm min) or a wiping action can be used to break through the oxide layer. When tungsten contacts must be used in a sensitive device with a light contact force (as in a thermally actuated time delay relay), the contacts may be sealed in hydrogen or an inert atmosphere to prevent oxide formation.

The properties of molybdenum fall between those of silver and tungsten. Molybdenum may replace silver in applications where greater wear resistance is required. It may also replace tungsten when low surface contact resistance is needed or when the application is not sufficiently severe to require the use of tungsten. Molybdenum possesses outstanding resistance to welding and wear and is widely used in semicontinuous operations (low voltage vibrators and telegraph relays). It is also used extensively for electrodes in mercury switches to form a good electrical connection without any chemical reaction or amalgamation.

Westinghouse Electric Corp.

Refrigerator thermostat *contacts must possess low and uniform contact resistance and good resistance to oxidation and corrosion. Most commonly used materials include fine silver, silver-cadmium and silver-palladium.*

Sintered metal powders

A whole new class of contact materials, known as high conductivity-refractory materials, became available when methods were developed for sintering silver or copper with refractory metals such as tungsten and molybdenum and their carbides. A unique advantage provided by sintering is that the combination of metals retains the specific characteristics of each component. Some of these characteristics, notably conductivity, may be lost in conventional alloys. Thus, sintered contacts of this type exhibit the high conductivity of silver or copper plus the high arc resistance and freedom from sticking or welding of the refractory component.

Another class of sintered materials, known as high conductivity semirefractory materials, consists of a high conductivity metal (silver or copper) combined with a semirefractory material (which may be a metal, metalloid or metallic oxide). These latter materials may be considered high conductivity materials whose properties have been modified by the addition of refractory substances, whereas the former types are essentially refractory materials whose properties have been modified by the addition of high conductivity metals.

4. Determine the Contact Design

Size

The size of a contact depends primarily on the current to be carried, the temperature rise that can be tolerated, and the contact life desired. Because contacts are frequently made from rare or costly materials, it is often necessary to keep their size as small as possible.

For silver contacts between ⅛ and ¼ in. in dia, a current density of about 50 amp per sq in. is generally recommended. Within this range there is an approximate straight-line relationship be-

tween the contact diameter and the current that can be carried. It is a conservative relationship for currents up to about 20 or 30 amp.

In general, the current that can be safely interrupted varies inversely as the product of the frequency of operation and the impressed voltage. Contacts of a given size can safely interrupt about 1½ to 2 times as much current in an a.c. circuit as they can in a d.c. circuit, assuming that the product of operating frequency and impressed voltage is the same in both cases. Thus, in d.c. circuits, contact diameters should be 1½ to 2 times larger than those in a.c. circuits. Thickness of the contact is governed primarily by the desired contact life and the temperature rise expected during operation.

Shape and style

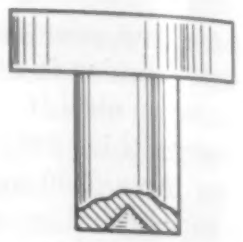
One flat and one radiused contact usually provide satisfactory surface area and greatest ease of alignment. Contact radius depends on a number of factors, but a general rule is that the radius should be about two to four times the contact diameter.

Choice of contact style or type of construction depends to a considerable extent on the contact material. Some materials cannot be made in certain styles and must be fabricated in special ways to prevent cracking or other damage (see chart on Common Shapes and Styles of Electrical Contacts on this page).

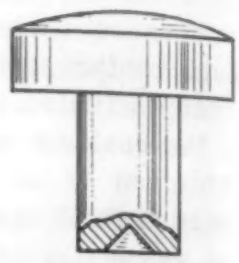
Gap and opening speed

In a d.c. circuit with inductance, contact spacing and opening speed should be great enough to prevent excessive arcing across the contacts before the higher peak voltages are induced. In such circuits, sudden release of inductive energy may be so high as to cause damage to coil insulation and other components. An arc suppression circuit may be necessary if the opening speed cannot be increased sufficiently. In d.c. circuits a high rate of speed, such as snap-action, can frequently reduce arc erosion and material transfer.

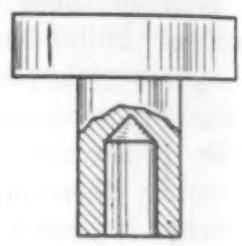
Common Shapes and Styles



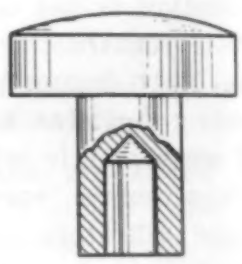
Solid rivet, flat face, standard divot in shank (optional). Available in fine coin silver, silver alloys, some platinum and palladium alloys.



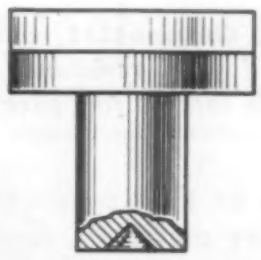
Solid rivet, radiused face, standard divot in shank (optional). Available in same contact materials as flat face solid rivet above.



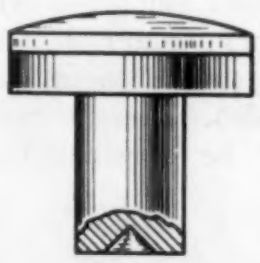
Solid rivet, flat face and tubular shank. Available in same materials as solid rivets above.



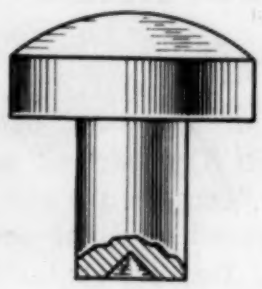
Solid rivet, radiused face and tubular shank. Available in same materials as solid rivets above.



Composite rivet, flat face, standard divot in shank (optional with solid or tubular shank). Available in all materials. Composite rivet must be used with non-ductile materials (platinum group alloys, tungsten, molybdenum and highly refractory sintered metal powder combination).

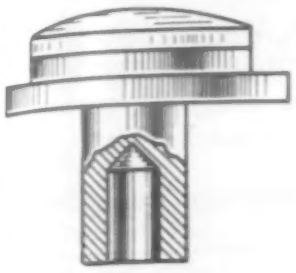


Composite rivet, radiused face, standard divot in shank (optional with solid or tubular shank). Materials: see previous note for flat face composite rivet.

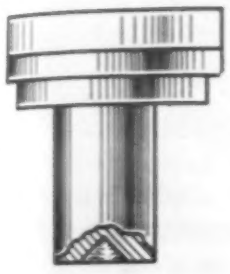


Puddled composite rivet, naturally radiused face, standard divot in shank (optional with coined radius and/or solid tubular shank). Available only in materials with low melting point.

of Electrical Contacts



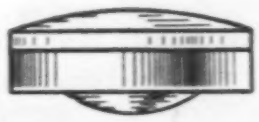
Flange-type rivet, tubular shank (optional with solid shank or with standard divot in shank). Often used to forestall cracking in non-ductile materials since assembly tool can rest against backing member instead of contact face.



Shoulder-type rivet, divot in shank. Often used to avoid cracking in non-ductile materials since assembly die can rest against backing member instead of back of contact.

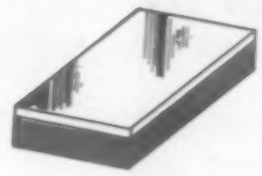
Composite steel back, flat face, broken edge, center projection for welding. Available in fine and coin silver, silver-copper-nickel, silver-cadmium, silver-palladium, silver-platinum, platinum-palladium, platinum-group alloys. Backing may be steel, nickel plated steel, silver plated steel, monel, nickel, nickel silver or other.

Composite steel back, radiused face, center projection for welding. Available in same materials as flat face composite steel back above.

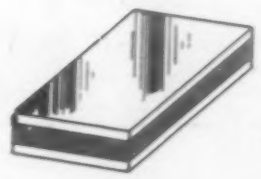


Screw. Straight, hexagon on contact end, or hexagon on thread end. Available in all materials. Used where adjustment of contact spacing is desired.

Collector ring or brush. Used to maintain continuity of one or more circuits in rotating devices such as gunfire control apparatus, radar equipment, servomechanisms, etc. Available in fine and coin silver, silver-palladium, silver-platinum, gold alloys, platinum alloys. For economy in larger sizes, material is laminated to copper, brass, bronze, monel, nickel silver or phosphor bronze.



Single overlay



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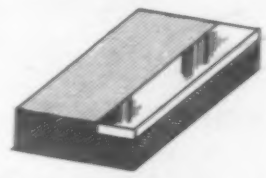
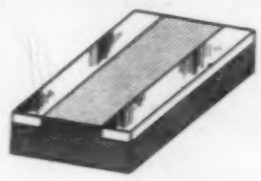


Single inlay



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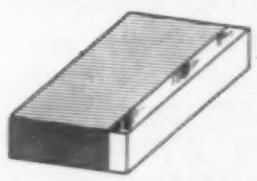
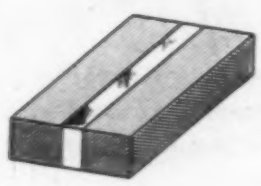
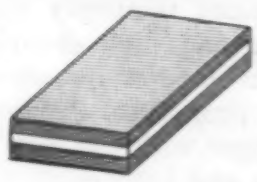


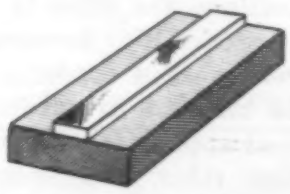
Edgelay



Thrulay



Centerlay



Ridgelay

Composite metal strip for special fabrication by blanking, forming, bending or drawing. Supplied in random lengths or in coils. Aids automatic assembly and often provides best combination of physical properties and greatest design flexibility. Available in fine and coin silver, some silver alloys, platinum, palladium and some precious metal alloys. Base metal may be copper, brass, bronze, nickel silver, phosphor bronze, beryllium copper, nickel, monel, steel or other.

In a.c. circuits the rate of opening should be such that the arc is extinguished at the first current zero and not reignited. Slow break and quick make are desirable to prevent contact wear. Because the energy dissipated is a function of arc length, a high opening speed across a wide contact gap produces greater energy dissipation. High opening speeds also produce higher peak voltages in inductive circuits and thereby increase arcing.

Contact force

To obtain maximum sureness of operation and minimum contact resistance and temperature rise, contact force on make should be the maximum possible without causing excessive mechanical wear.

Special Contact Backing Materials

In general, the characteristics required in contact backing members are: 1) high electrical and thermal conductivity; 2) high resilience; 3) high mechanical strength and hardness; and 4) high service temperature.

Copper meets the first of these requirements but does not possess very satisfactory mechanical properties for specialized contact applications. It can be hardened by cold working. However, since contacts are often assembled by brazing, soldering or welding at temperatures above copper's annealing temperature, the mechanical strength and hardness gained by cold working may be lost. The result is a backing member with low mechanical properties, poor spring qualities and low impact resistance.

Other materials such as brass, nickel silver, phosphor bronze, nickel, monel and steel have been used for backing members with varying degrees of success, but they possess much lower conductivity than copper and a number of other disadvantages.

Cadmium-copper

This alloy possesses relatively high strength and abrasion resistance and high electrical and thermal conductivity. It can be severely cold worked to obtain excellent physical properties. Thus, it combines the conductivity of copper with the high physical properties of the brasses and bronzes.

In most applications the alloy is used in the full hard condition. Occasionally, however, it is used in a more highly cold worked condition—as high as 80 to 90% when the ultimate in hardness and strength is required. Typical applications include contact arms, springs, reeds and other current-carrying members in a wide variety of devices including relays, circuit breakers and voltage regulators. The alloy is also used in many applications because of its good wearing properties and its tendency to quench an arc drawn on its surface.

Chromium-copper

Chromium-copper containing silicon can be heat treated to provide a combination of high electrical and thermal conductivity and high physical properties. It possesses excellent strength, yet is sufficiently ductile to be stamped and formed without splitting or cracking. Because it is heat-treatable, the alloy can be formed or fabricated in a relatively soft temper, then age hardened at 850 to 900 F for 1 or 2 hr to obtain high physical properties. These properties are not lost when the metal is brazed or welded.

The alloy's electrical conductivity is approximately 80% that of copper, but it provides much higher tensile strength and hardness than copper. Its fatigue strength and wear resistance are approximately twice that of pure hard drawn copper. Typical applications include current-carrying terminals, nuts, studs, bolts and circuit breaker parts and other contact-supporting members that must be subjected to high temperatures during brazing, soldering or welding.

Beryllium-cobalt-copper

This alloy possesses fairly high conductivity and can be heat treated to develop unusually high physical properties. Its combination of relatively high conductivity (50%), hardness, proportional limit and fatigue strength make it an excellent current-carrying spring material. Cross sections of springs often can be reduced when the alloy is used in place of ordinary spring materials. Intricate parts can be formed in the soft-annealed condition when the metal is highly ductile, then heat treated at 850 to 900 F for 1 or 2 hr.

Beryllium-cobalt-copper possesses appreciably higher hardness and physical properties but lower conductivity than chromium-copper. The choice between the two alloys usually depends on whether maximum physical properties or maximum conductivity is required. In some applications, the lower price of chromium-copper may be the deciding selection factor.

Principal applications include spring arms, reeds and other contact-carrying members in relays, switches and circuit breakers. The alloy is also used for switch blades, slip rings and collector rings in high speed applications, and for intricate circuit breaker parts.

Beryllium-copper

Beryllium-copper can be heat treated to produce the maximum hardness and physical properties obtainable in a copper-base alloy. Compared to spring steel, the alloy possesses considerably higher conductivity, slightly lower hardness and about the same endurance limit. Its wearing qualities are unequaled by any other nonferrous alloy. It possesses higher spring qualities and hardness, but lower conductivity than the other special alloys described above.

Intricately shaped parts can be formed from the alloy in the soft-annealed condition, then age hardened at 600 to 650 F for 1 to 2 hr to obtain a combination of high physical properties and good conductivity. Since the alloy has a maximum service temperature of about 700 F before softening occurs, soft soldering does not affect its physical properties. Applications include vibrator arms, springs, spring washers and similar parts requiring high elastic limit and yield point combined with excellent fatigue properties and good conductivity.

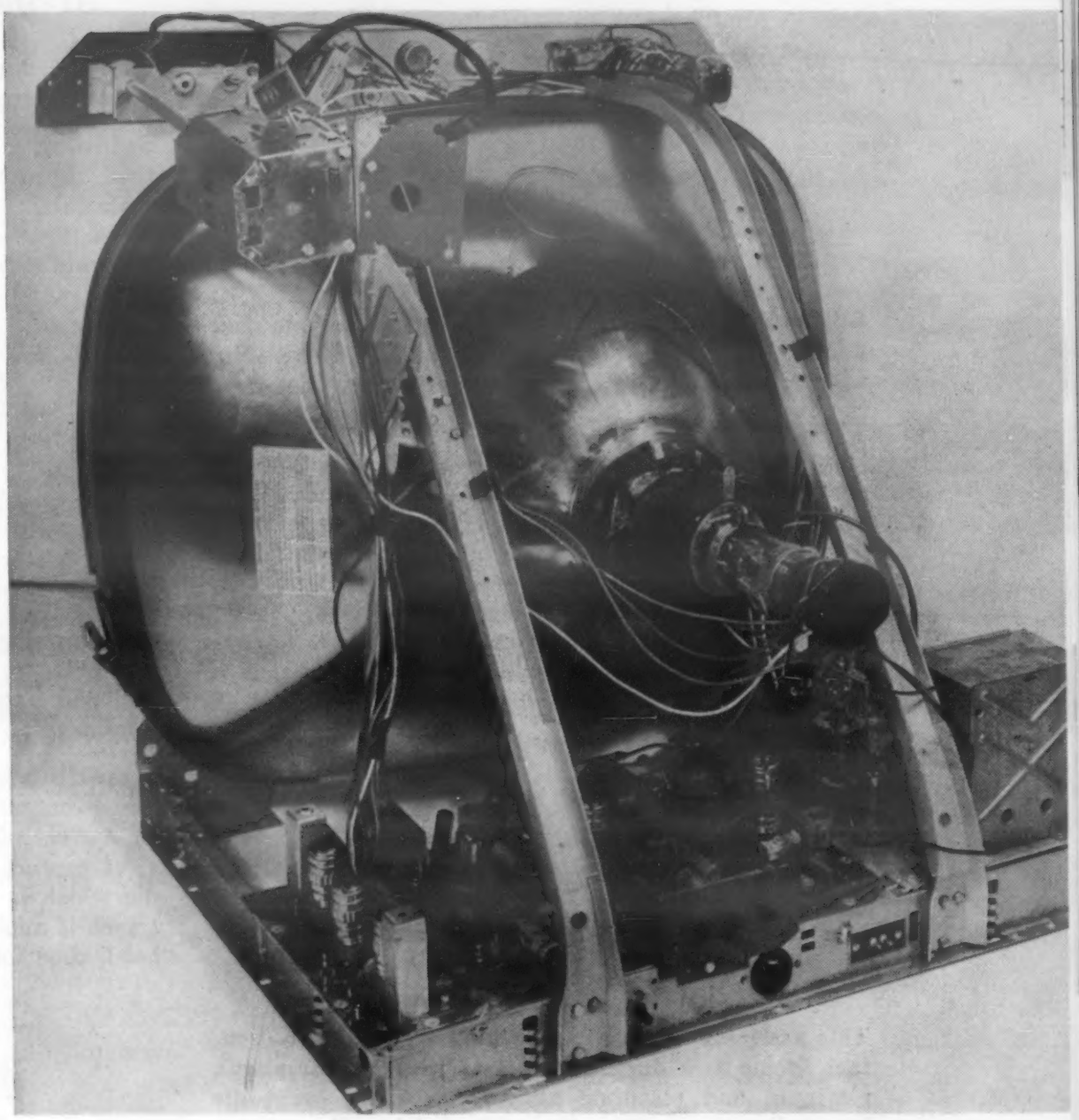
An increase in contact force to lower contact resistance is particularly desirable for materials that tend to form oxides, sulfides or other insulating films. Material transfer, however, can sometimes be reduced by a decrease in contact force.

Method of operation

To minimize accumulation of dirt and other foreign materials, contacts should operate in a vertical plane wherever possible. To assist in breaking down oxide and chemical films, it is frequently desirable to incorporate a wiping or sliding action between contacts. Wiping action is also desirable in many devices where heavy cam or mechanical forces are available. It should not be used, however, where material transfer is expected, where light pressure must be used, or with soft materials.

Method of assembly

The method of contact assembly is an important factor, not only in the final performance of contacts, but in the selection and design of contact materials. Some materials are particularly well suited to certain methods of assembly, whereas in other applications a compromise must be made in assembly because of the nature of the material. In gen-



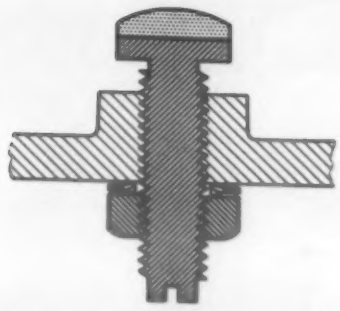
Westinghouse Electric Corp.

***Television control** contacts are usually fabricated from alloys of silver-copper-nickel, silver-palladium, silver-cadmium or silver-tungsten.*

TABLE 3—PROPERTIES OF STANDARD SPRING MATERIALS AND SPECIAL ALLOYS USED FOR CONTACT BACKING

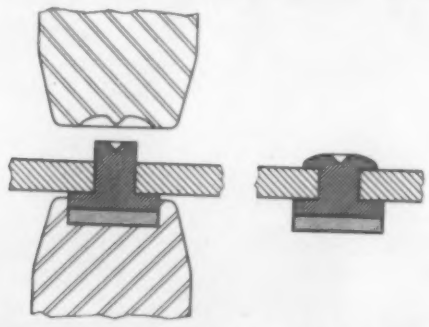
	Tensile Strength, psi	Yield Strength, psi	Rockwell Hardness		Elect. Cond., % IACS	Thermal Cond., Btu/sq ft/hr/F/in.	Max Service Temp F
			Soft	Hard			
STANDARD SPRING MATERIALS							
Copper	48,000	40,000	37F	50B	100	2700	300
Yellow Brass	73,000	60,000	13B	80B	27	830	400
Grade A Phosphor Bronze	82,000	67,000	25B	85B	18	565	500
18% Nickel Silver	85,000	70,000	40B	88B	6	230	800
Monel	110,000	95,000	70B	98B	4	180	700
SAE 1010 Steel	56,000	38,000	55B	85B	12	525	600
SAE 1095 Spring Steel[a]	185,000	115,000	90B	42C	7	430	400
18-8 Stainless Steel	175,000	160,000	83B	32C	2	113	1000
SPECIAL ALLOYS							
Cadmium-Copper	64,000	55,000	47F	75B	85	2390	575
Chromium-Copper[a]	76,000	61,000	50F	78B	80	2250	900
Beryllium-Cobalt-Copper[a]	120,000	90,000	35B	97B	50	1740	900
Beryllium-Copper[a]	190,000	150,000	50B	40C	25	650	700

Full hard, cold worked, heat treated condition. Properties of remaining materials are for full hard, cold worked condition only.

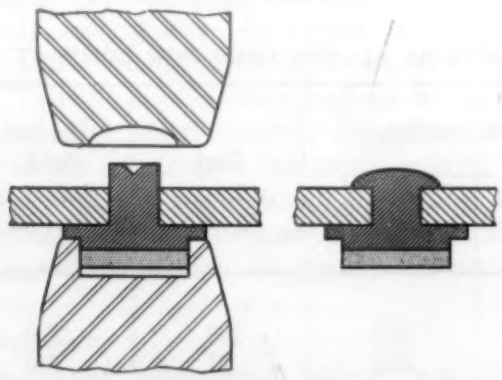


Adjustable screw contacts are used to provide easy gap adjustment and to allow for contact wear. Nut and lock washer are commonly used for contact positioning, but other fastening methods are available.

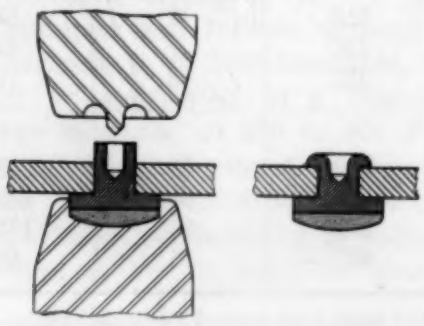
Riveting or staking is one of the most common methods of contact assembly. Assembly is easy and rapid, can be done with inexpensive equipment such as a punch press or a riveting machine, and is adaptable to many automatic feeding devices. With conventional solid or composite rivets, the lower die is machined to fit the contact face (either flat or radiused) and the upper punch is formed so that it will center properly in the divot of the rivet shank . . .



This assembly method can be used only when the contact facing is a ductile material (silver, silver alloys, platinum and platinum alloys), since the lower die bears directly against the contact face. To prevent cracking of non-ductile contact facings (tungsten, molybdenum and the highly refractory sintered compositions), a shoulder-type rivet is commonly used. The lower die is so shaped that it bears firmly against the shoulder of the metal backing, but is entirely clear of the contact facing . . .

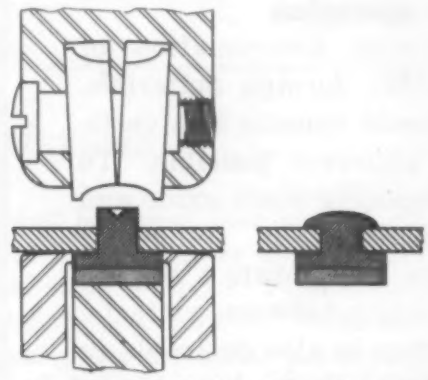


Instead of a divot, many rivet contacts are made with a hollow or tubular shank to prevent distortion of the contact blade during assembly . . .



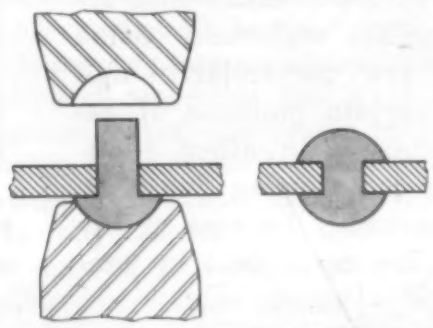
Uniform flow of the shank material is obtained by light impact or pressing action.

Spinning is an alternate method of contact assembly used to prevent the cracking of non-ductile facing materials. The lower die has an undercut collet which grips the base metal portion of the rivet firmly and prevents it from rotating . . .



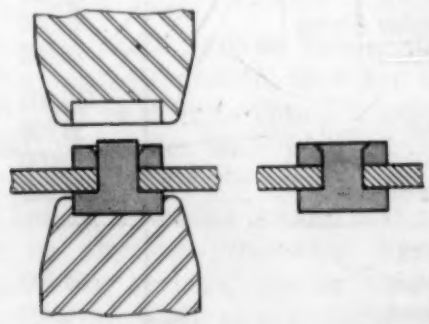
The spinning tool is applied to the shank with increasing pressure to produce a gradual build-up of heat and make the metal flow more easily so that only a minimum of pressure is required.

Upsetting is most commonly used to make a double-faced contact assembly from either 1) a solid rivet or 2) a rivet plus a washer. In the first method a solid rivet contact with a long shank is placed in a lower die which is shaped to fit the rivet head. The upper punch is applied to the shank to upset it into a contact head, thus forming a double-faced contact . . .



The shank must be the correct length to provide the proper amount of stock for the contact shape desired. Upsetting by this method can be difficult on very thin blades, since the force required to head the shank may cause some distortion. This condition can be overcome by hot upsetting.

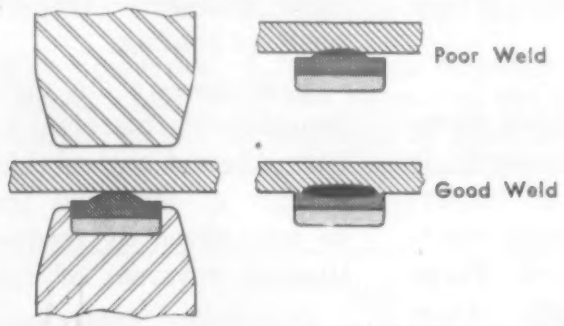
In the second method the shank and a washer are combined to form the upper contact head. The washer is made of the same material as the contact shank and is usually made with a slight countersink to provide a tight assembly. The rivet shank is coined flush with the surface of the washer so that it will fill up and interlock with the countersunk portion . . .



The assembly is not satisfactory for heavy duty applications since the second head is merely a close-fitting mechanical assembly.

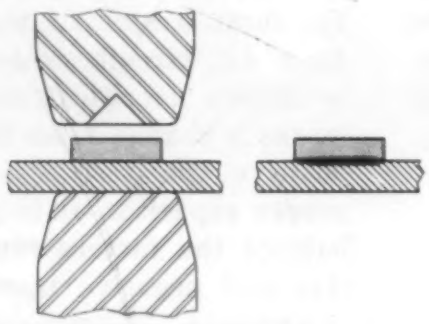
—And Where They're Used

Projection welding of solid or composite button-type contacts is accomplished by localizing the heat during resistance welding to a projection on the back of the contact . . .



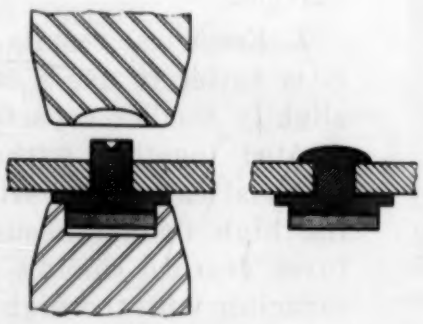
Projection welding is commonly used for precious metal contacts with steel, nickel or other nonferrous metal backings. It is also used with tungsten contact assemblies in which the tungsten disk is brazed to a steel backing with a welding projection. Contacts of fine silver, platinum, palladium and their alloys, when formed with a suitable welding projection, can be welded directly to copper, brass, nickel silver, steel or other metals.

Spot welding differs from projection welding in that no projection is used for localizing the heat. In some cases the upper electrode may be countersunk to provide localized heating and pressure at the edges of the contact disk . . .



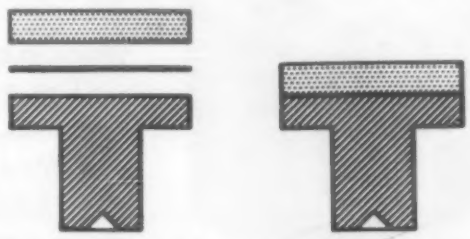
The method is most suitable for welding high-resistance contact materials (tungsten and some of the platinum and palladium alloys) to backing materials which also have relatively high resistance, (nickel, nickel silver, nickel plated steel, etc.)

Electrical upsetting is similar to mechanical staking or riveting except that it is done in a resistance welding machine. Either a solid or a composite rivet may be used, but in general a shoulder-type rivet is used to prevent any deleterious effect on the contact face. During welding sufficient heat is developed to soften the metal shank and flow it over, so that a firm bond is made between the backing material and the upset shank . . .



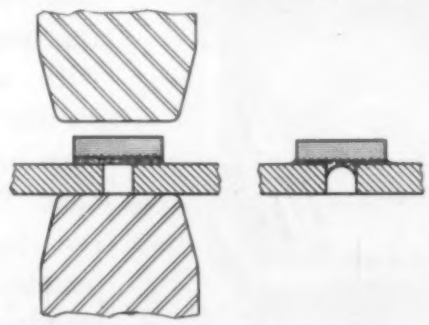
In many cases, the upset shank is simultaneously welded to the backing material to insure minimum contact resistance.

Furnace brazing requires the use of a third material with a melting point lower than the contact facing or the backing member. When melted, the brazing alloy either wets both surfaces or actually alloys with the materials to form an integral bond . . .



The process may be used to assemble a contact facing to a contact arm, or to fasten a solid or composite rivet in a hole in the backing material. Furnace brazing is generally used for the mass production of small parts in which the bond is so designed that the contact becomes self-centering.

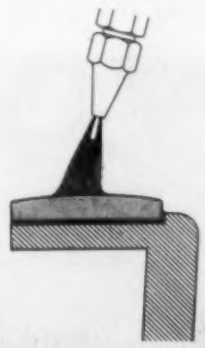
Electrobrazing may be considered as a combination of welding and brazing. Pressure, plus heat generated from the passage of current through the parts to be joined, melts and flows the brazing alloy . . .



Electrobrazing is often used when large parts are involved, or when furnace brazing or torch brazing cannot be used. Since heating can be closely confined, the process is frequently used when the final assembly must not be annealed.

Torch brazing is used to assemble large parts or special shapes and sizes which are difficult to join by other methods.

A reducing flame is usually used, and flux is frequently employed to protect the parts from excessive oxidation. A silver solder or other brazing material forms the joint . . .



Induction brazing provides rapid and localized heating and excellent brazed joints can be produced over large areas. Silver solder or other brazing material is used between the contact facing and the backing member, or the contact facing may be supplied with a solder-flushed backing. Pressure is frequently applied to hold dimensions and to squeeze out excess solder. Because of localized heating, hardness and strength of the backing material is affected only at the brazed area.

Circle F Mfg. Co.

***Medium duty switch** with slow make and break utilizes fine silver contacts.*

Sperry Rand Corp.

***Razor** contacts are fabricated from tungsten or platinum-iridium alloy.*

eral, a brazed, soldered or welded construction is best for assemblies that must carry heavy currents or withstand high ambient temperatures (see chart on Methods of Assembling Contacts and Where They're Used, p 138).

Backing material

The arm, spring or other member on which the contact is mounted is frequently an important factor in the successful operation and life of a contact. These parts, commonly made from brass, copper, steel and bronze, are often plated with silver, nickel or copper to increase conductivity or prevent corrosion. In addition to these common backing materials, several special alloys with unusual combinations of properties—such as high electrical and thermal conductivity combined with superior hardness, fatigue strength or resistance to corrosion and creep—have been developed for particular applications (see Special Contact Backing Materials, p 136). Properties of standard and special backing materials are given in Table 3.

Other factors

Inductance—In some cases, material transfer obtained on the negative contact can be decreased by increasing the inductance of the circuit. Above a critical limit, however, high inductance will produce excessive transfer on the positive contact.

Polarity—In d.c. circuits where considerable material transfer occurs, the net material loss and the danger of localized transfer can be minimized by frequent or continuous reversal of polarity.

Dissimilar materials—Material transfer, particularly in d.c. circuits, can in many cases be decreased or eliminated by using dissimilar materials for the positive and negative contacts.

Auxiliary protection—Material transfer can be decreased in both a.c. and d.c. circuits by using an arc-quenching circuit with the proper capacitance and resistance across the contacts. When a capacitor is used alone in an a.c. circuit it merely serves to limit the total erosion of the contacts. In a d.c. circuit, however, there is always a critical current that marks a change from negative to positive transfer. By using the proper capacitor, it is possible to balance the factors causing positive and negative transfer.

Although capacitors are usually selected on the basis of actual tests, the following rules can be used to establish their size:

1. For a.c. circuits up to 440 v, use approximately 1 mf for each 30 millihenries of inductance per 7½ peak amp on break of primary current.

2. For d.c. circuits up to 300 v, use approximately 1 mf for each 25 millihenries of inductance per 5 peak amp on break of primary current.

3. Empirical results show that it is better to use a capacitor of slightly smaller capacity than indicated together with a contact material capable of withstanding the high instantaneous temperatures reached during arcing. A capacitor with too high a capacity will almost always result in poor performance.

Western Electric Co.

***Telephone dial** contacts operate under low voltages and currents and light contact pressures. Silver-palladium and palladium are most commonly used.*

Reprints of this and other Manuals are available at 35¢ each until supply is exhausted. See p 192 for complete list of available Manuals. Write for quotations on quantities of 100 or more. Address requests to Reader Service Dept., MATERIALS & METHODS, 430 Park Ave., New York 22, N.Y.

SEPTEMBER 1956

MATERIALS ENGINEERING FILE FACTS

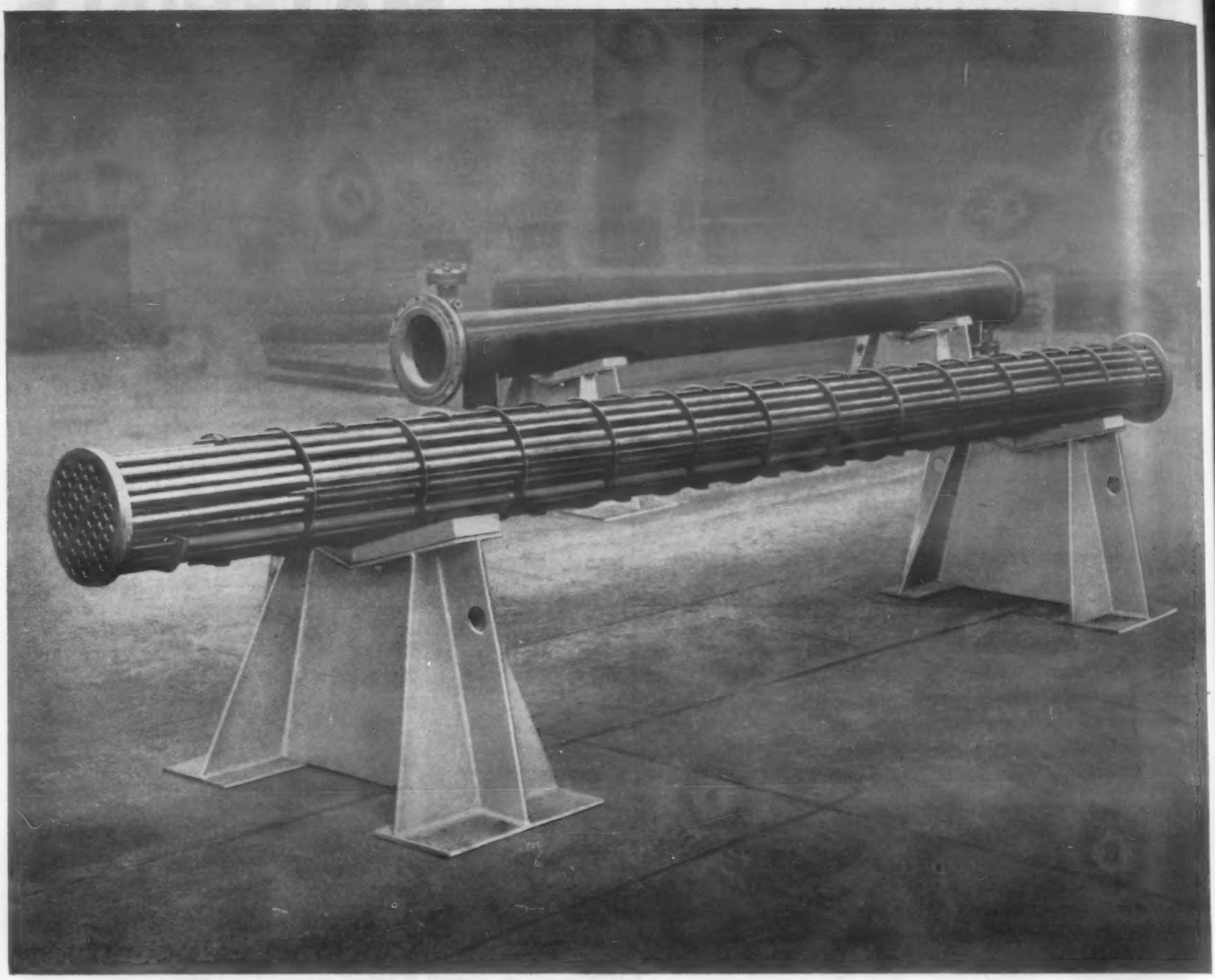
Nodular or Ductile Irons—a Materials Data Sheet

The properties of this group of materials lie between those of gray irons and those of cast carbon steels. They can be cast at the same temperatures and by the same procedures as gray iron. They can be improved by heat treatment procedures used for cast carbon steels.

Type	80-60-3	60-45-10	100-75-04[a]
COMPOSITION, %	T.C. 3.3-3.8 Si 2.0-3.0 Mn 0.2-0.5 P 0.06-0.08 Ni 0-1.0 Mg 0.02-0.07	T.C. 3.4-4.0 Si 2.0-2.75 Mn 0.2-0.6 P 0.06-0.08 Ni 0-1.0 Mg 0.02-0.07	T.C. 3.4-3.8 Si 2.0-2.75 Mn 0.3-0.6 P 0.08 max Ni 0-2.5 Mo 0-1.0 Mg 0.02-0.07
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.257	0.257	0.257
Melting Temperature Range, F	2050-2150	2050-2150	2050-2150
Thermal Cond (212 F), Btu/hr/sq ft/ft/F	18	20	—
Coeff of Expansion per F (70-400 F)	6.6×10^{-6}	6.6×10^{-6}	6.6×10^{-6}
Elect. Resistivity (75 F), microhm-cm	68[b]	66[b]	—
MECHANICAL PROPERTIES			
Modulus of Elasticity in Tension, psi	$22\text{-}25 \times 10^6$	$22\text{-}25 \times 10^6$	$22\text{-}25 \times 10^6$
Tensile Strength, 1000 psi	90-110	60-80	100-120
Yield Strength, 1000 psi	60-75	45-60	75-90
Elongation in 2 in., %	3-10	10-25	6-10
Hardness, Brinell	200-270	140-190	200-240
Impact Strength, Charpy, ft-lb:			
Unnotched	15-65	60-115	35-50
Notched	2-5	10-15	—
Fatigue Strength	Endurance ratio follows pattern set with other ferrous materials. For soft ferritic materials, the notched endurance ratio runs from 50-55%; with the stronger irons, the ratio drops to 30-40% or lower		
Compressive Strength	Ratio of compressive strength to tensile strength is about 2 to 1		
Creep Strength (0.0001%/hr), psi			
800 F	19,000	14,000	—
1000 F	1750	4000	—
1200 F	480	550	—
1400 F	—	—	—
THERMAL TREATMENT			
Ferritic Structure (ferritizing anneal)	Heat in 1600-1650 F range, cool to 1300 F, hold 1-3 hr, furnace cool to 1100 F, air cool		
Pearlitic-Ferritic Structures	Heat to 1600-1650 F, cool rapidly, reheat at 1100-1300 F		
Pearlitic Structures	Normalize by air cooling from 1600-1650 F		
Tempered Structures	Quench from 1400-1650 F depending on composition, temper at 800-1300 F		
FABRICATING PROPERTIES			
Machinability	Depends on structure but has excellent machinability in both as-cast and annealed conditions		
Weldability	Can be welded by most fusion welding processes. For maximum ductility, welding should be done on fully annealed material. Composition affects weld quality. A 60 Ni-40% Fe filler wire is best for metal arc welding. Can be brazed with the lower melting BAg filler metals		
CORROSION RESISTANCE	Approx same corrosion resistance as gray irons of similar compositions		
USES	Anvils for forging hammers; impellers, levers, cams, crankshafts, dies, jet engine burner support rings	Valve and pump bodies, pipe fittings, clamps, gear housings, tractor and farm machine parts	Track shoes, brake drums, gears, cam shafts, pistons

For more information, Circle No. 571

(continued on p 145)



TITANIUM...Strongest Defense Against "All-Out" Attack

In the ceaseless battle against corrosion, B&W Seamless Titanium Tubing is providing a first and most powerful defense.

B&W Titanium Tubing is the practical result of many years of experience in making tubes of carbon steels, stainless steels, other alloys. It superbly combines maximum corrosion resistance and easy workability.

For example, the superior qualities of B&W Titanium Tubing made it the natural choice of Struthers Wells Corporation for fabricating the all-titanium heat exchanger shown above. This unit, now performing perfectly in service, is 12 ft. long, x 17½ inches diameter and weighs 2200 lbs.

This case, like many others, shows how B&W Seamless Titanium Tubing met the need and solved the problem for a fabricator.

Get answers to *your* questions on why to use . . . what to use . . . how to use titanium tubing . . . call on Mr. Tubes. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

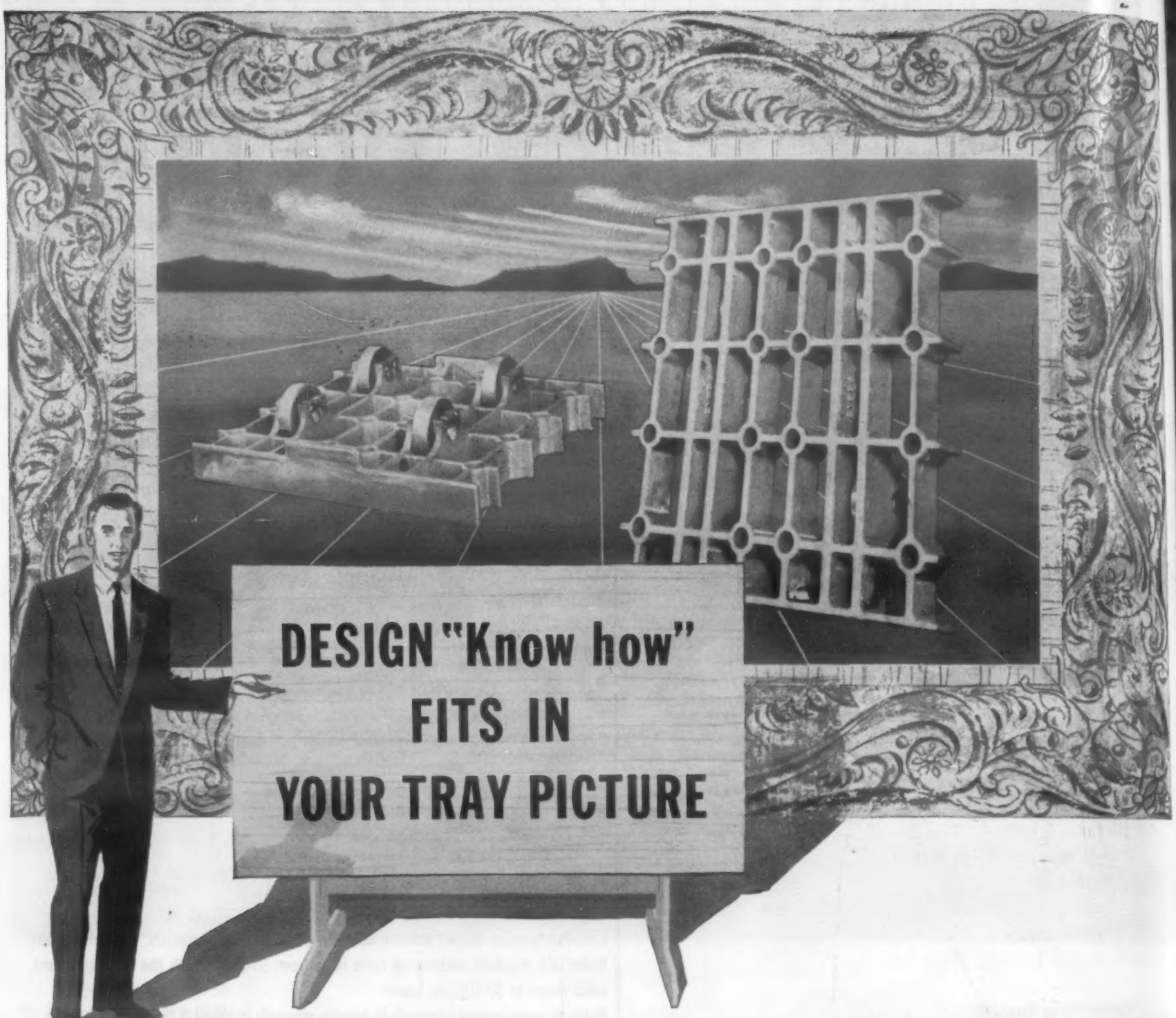
Seamless and welded tubular products, seamless welding fittings and flanges—in carbon, alloy and stainless steels

For more information, turn to Reader Service Card, Circle No. 389

Nodular or Ductile Irons — Continued

Type	120-90-02[a]	Heat Resistant	Austenitic
COMPOSITION, %	T.C. 3.4-3.8 Si 2.0-2.75 Mn 0.3-0.6 P 0.08 max Ni 0-2.5 Mo 0-1.0 Mg 0.02-0.07	T.C. 2.8-3.8 Si 2.5-6.0 Mn 0.2-0.6 P 0.08 max Ni 0-1.5 Mg 0.02-0.07	T.C. 3.0 Si 2.0-3.2 Mn 0.8-1.5 P 0.02 max Ni 18-22 Cr 0-2.5
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.257	0.25	0.268
Melting Temperature Range, F	2050-2150	2050-2150	2250
Thermal Cond. (212 F), Btu/hr/sq ft/ft/F	—	—	—
Coeff. of Expansion per F (70-400 F)	6.6×10^{-6}	—	10.4×10^{-6}
Elect. Resistivity (75 F), microhm-cm	—	—	102
MECHANICAL PROPERTIES			
Modulus of Elasticity in Tension, psi	$22\text{-}25 \times 10^6$	$22\text{-}25 \times 10^6$	18.5×10^6
Tensile Strength, 1000 psi	120-150	60-100	58-68
Yield Strength, 1000 psi	90-125	45-75	32-38
Elongation in 2 in., %	2-7	0-20	7-40[c]
Hardness, Brinell	240-325	140-300	140-200
Impact Strength, Charpy, ft-lb			
Unnotched	25-40	5-115	—
Notched	—	—	10-28[d]
Fatigue Strength	Endurance ratio follows pattern set with other ferrous materials. For soft ferritic materials, notched endurance ratio runs from 50-55%; with the stronger irons, ratio drops to 30-40% or lower		
Compressive Strength	Ratio of compressive strength to tensile strength is about 2 to 1		
Creep Strength (0.0001%/hr), psi			
800 F	—	—	18,500
1000 F	—	—	13,000
1200 F	—	—	5700
1400 F	—	—	2000
THERMAL TREATMENT			
Ferritic Structure (ferritizing anneal)	Heat in 1600-1650 F range, cool to 1300 F, hold 1-3 hr, furnace cool to 1100 F, air cool		—
Pearlitic-Ferritic Structures	Heat to 1600-1650 F, cool rapidly, reheat at 1100-1300 F		—
Pearlitic Structures	Normalize by air cooling from 1600-1650 F		—
Tempered Structures	Quench from 1400-1650 F depending on composition, temper at 800-1300 F		—
FABRICATING PROPERTIES			
Machinability	Depends on structure but has excellent machinability in both as-cast and annealed conditions		
Weldability	Can be welded by most fusion welding processes. For maximum ductility, welding should be done on fully annealed material. Composition affects weld quality. A 60 Ni-40% Fe filler wire is best for metal arc welding. Can be brazed with the lower melting BAg filler metals		
CORROSION RESISTANCE	Approx same corrosion resistance as gray irons of similar composition		
USES	Machine guides, pinions, gears, cams, dies, track rollers	Grate boxes, sinter pots, lead pots, glass molds, furnace doors	Impellers, grids, paper mill machine parts, pumps, valves

[a]Obtained by heat treatment involving normalizing or quenching and tempering. [b]Iron containing 1% Si. [c]25-40% with 0% Cr. [d]"V" notched.



Thermalloy* Trays give longer service life

The successful performance of heat-treat trays depends on *design,* as much as on any other factor. Many hours can be added to their life through the use of proper design methods. It is this design know-how that gives Electro-Alloys Thermalloy Trays better service life.

The continuous operation under high temperatures calls for a tray made of a metal that can resist heat and yet meet hard service requirements. (Thermalloy meets all of these requirements.)

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Contact your local Electro-Alloys representative or write Electro-Alloys Division, 7029 Taylor Street, Elyria, Ohio.

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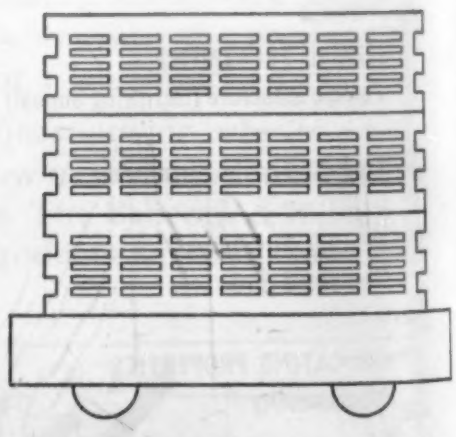


These trays are designed to carry maximum work loads for each specific application.

Heat-Resistant Castings • Trays • Muffles • Conveyor Belts • Retorts • Radiant Tubes

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

Elyria, Ohio

For more information, turn to Reader Service Card, Circle No. 377

NEW MATERIALS PREVIEWS

This month

- *A silver-like electroplate*
- *Teflon gaskets that don't flow*
- *Other new materials, p 151*

***Silverware, tableware** are electroplated with copper-tin alloy for tarnish-free service over long periods.*

Hard, ductile, tarnish resistant . . .

50-50 Copper-Tin Electroplate Resembles Polished Silver

■ A 50-50, copper-tin alloy coating is provided by a new electroplating process developed by *Danmark Cunit, Inc.*, 223 E. 74th St., New York 21. The compact, nonporous coating is claimed to furnish high oxidation and tarnish resistance for long periods. Plated parts have a deep white luster and closely resemble polished silver.

The coating maintains its original color at temperatures up to its melting point—about 1450 F. Hardness and abrasion resistance are said to be superior to nickel plate.

The ductile coating is produced in a cyanide bath with a pure copper anode and current densities up to 140 amp per sq ft. Throwing power of the bath is excellent and uniform coatings have been applied to the inside of tubes and crevices of highly intricate parts. About 20 min are required to apply the standard 0.3- to 0.4-mil coating.

Principal applications of the coating to date have been silverware and tableware. Additional applications foreseen include automobile decorative hardware, appliance bodies, knobs, handles, etc.

The coating has been successfully applied to brass, copper, silver, and low and high carbon steels. Certain alloy steels have also been coated after application of a copper flash coat. Brass has proved quite popular as a base metal for the coating because of the ease with which it can be stamped, formed and machined.

(more New Materials on p 149)

often copied—never equalled

. . . and in high speed steels, nothing has ever equalled REX

Crucible's REX® high speed steel is in a class by itself—has been for more than half a century. And it gets better every year. New improvements in manufacturing techniques have brought even greater uniformity and quality to its well-known properties.

But prove this for yourself—shop-test the new REX in your own plant. Check its structure, uniformity, response to heat-treatment—all-around tool performance. Try REX any way you like—you'll see for yourself why the new REX is still the *standard for comparison* in every high speed steel application.

You can get REX from stock from your nearby Crucible warehouse—or promptly by direct mill delivery. For further information on REX and the many other Crucible special purpose steels, send for the *Crucible Publication Catalog*—it's yours for the asking. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

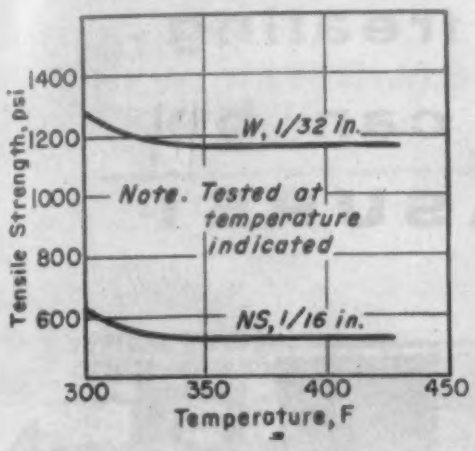
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

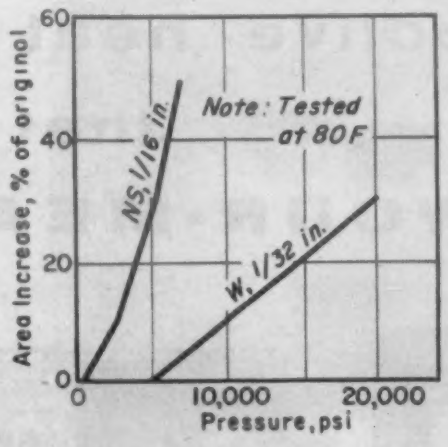
For more information, turn to Reader Service Card, Circle No. 379

These properties:

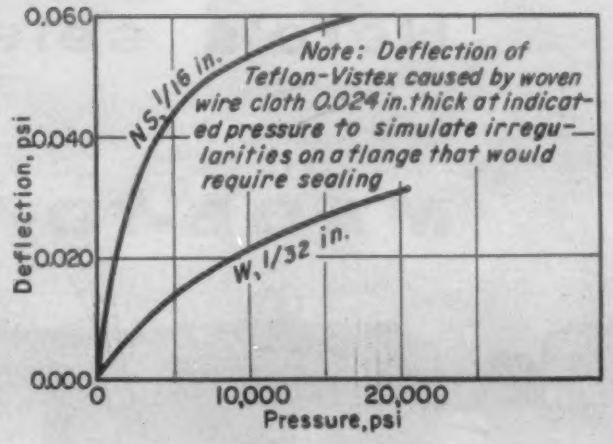
thermal stability . . .



low lateral flow . . .



good sealing . . .



make Teflon-impregnated felt an . . .

Improved Gasketing Material

■ The thermal and chemical properties of Teflon are now available in a gasketing material having low cold flow characteristics. Called Teflon-Vistex, it is a high pressure sheet stock laminate consisting of plies of mechanically interlocked synthetic fiber felt impregnated with Teflon resin.

The material, made by *American Felt Co.*, Glenville, Conn., has good stability to corrosive gases and liquids at low and high temperatures. It is claimed to offer economies over similar products. The nature of the synthetic fiber felt has not been disclosed.

Teflon-Vistex gaskets are made in two types that differ in gasketing action and compressive resilience properties. Type "W" is a tough, high tensile strength material for general purpose applications. Type "NS" is a moldable material suited for applications involving irregular flange surfaces and pressures. Both types are used for precision cut gaskets, strips and washers. The materials are available in thicknesses of 1/64 to 1/16 in.

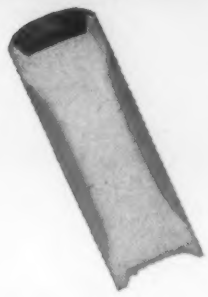
To test its stability, Teflon-Vistex was immersed for 36 hr at 70 F in various substances. The chemicals were: 70% sulfuric acid, 70% nitric acid, 37% hydrochloric acid, 50% sodium hydroxide, 28% ammonium hydroxide, 100% acetone and 100% carbon disulfide. Results for both Type "W" and "NS" were reported to be excellent. The material is thermally stable up to 420 F.

The material has good die- and hand-cutting properties. Its tear resistance is high and it does not ravel or fray. Lateral flow occurs only at pressures well above normal gasket pressures. Teflon-Vistex is said to seat properly despite bearing surface imperfections as great as the thickness of the gasket itself.

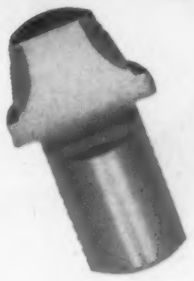
(Other New Materials on p 151)

PROPERTIES OF TEFLON-VISTEX

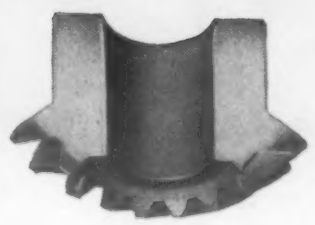
Properties	Type "W"	Type "NS"
Weight, oz/sq yd		
1/16 in.	64	64
1/32 in.	32	32
1/64 in.	16	16
Density, % specific gravity	136	136
Tensile Strength (min), psi	5000	900
Elongations to Rupture, %	60	250
Mullens Bursting Strength (min), psi		
1/16 in.	600	Does
1/32 in.	300	not
1/64 in.	150	break
Porosity, % voids	0	0
Shrinkage (in 212 F water), %	0	0
Air Permeability, cfm/sq ft/0.5 in. H_2O	0	0
Water Permeability, gpm/sq ft/1.0 psi	0	0



Transmission pinion pin



Locking pin

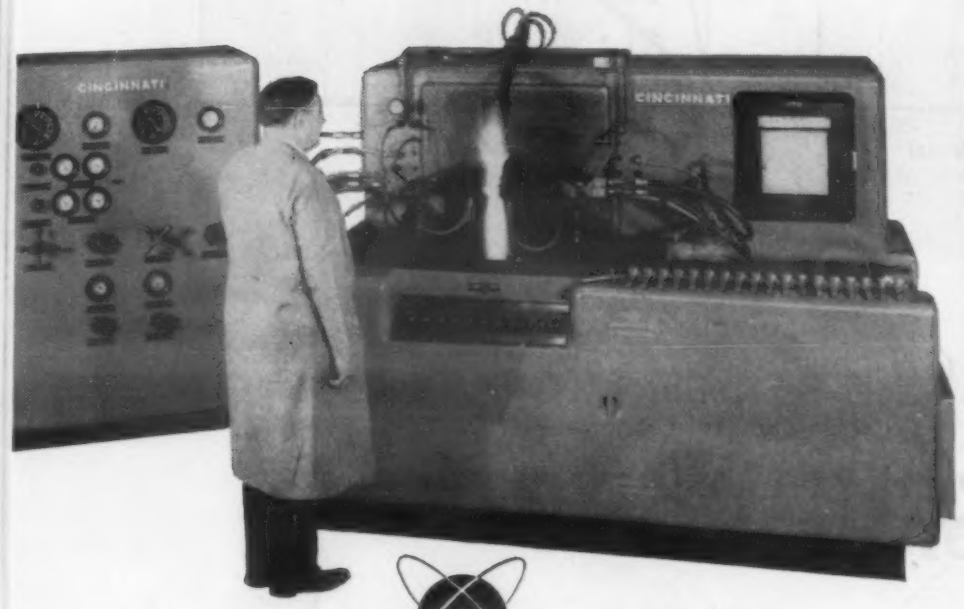


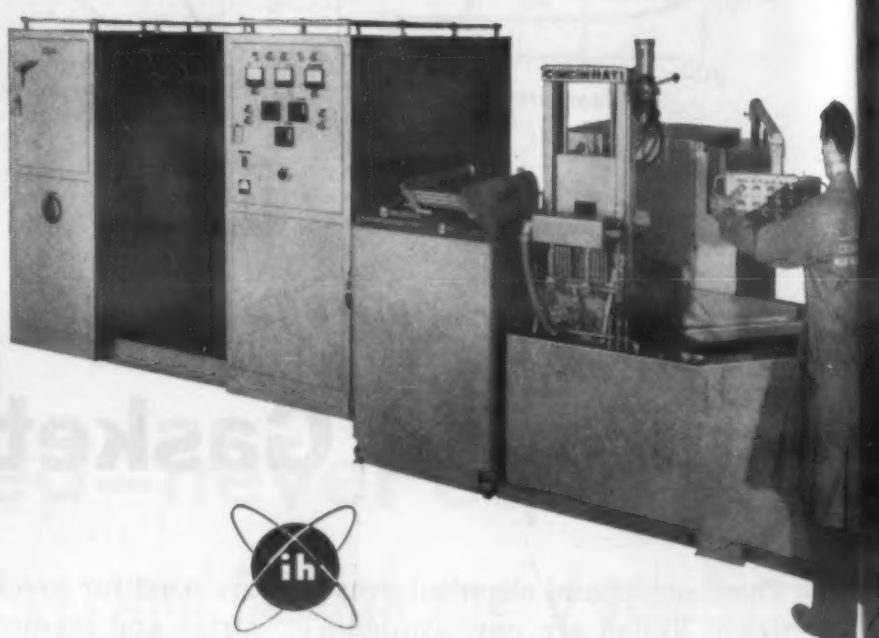
Bevel gear

Steering arm ball stud

Locking pawl

Here's selective heat treating that can be MADE-TO-YOUR-MEASURE!





flamatic flame hardening

induction hardening

Cincinnati does both — selective flame or induction hardening — and the parts shown above are typical of those that can be hardened by either method. If that's your situation, then talk to Cincinnati . . . headquarters for equipment that gives you the hardness wanted, where it's wanted, using the heat source most economical for you. Use electric power—or acetylene, propane, natural or manufactured gas—whichever is readily available to you or provides lowest cost.

Whether flame or induction, you can be assured of heat-treating machinery that will deliver the hardness you specify, and meet your cost-per-piece requirements, on high production quantities or varied, small-lot runs. It will be excellently engineered, equipped with the finest of components, thoroughly safeguarded, easily maintained.

Call in a Process Machinery Division field engineer. He is ideally equipped to evaluate your needs and give you unbiased recommendations as to the most economical equipment for your selective surface hardening work.

CINCINNATI

THE PROCESS MACHINERY DIVISION

flamatic induction

***Unplasticized PVC** was used for these vacuum formed packages.*

OTHER NEW MATERIALS PRODUCTS

Thermoplastic Sheet Materials for Vacuum Formed Products

New thermoplastic sheet materials recently introduced include unplasticized polyvinyl chloride sheet now being used in Germany for food packaging, extruded linear polyethylene and extruded styrene copolymer.

1. PVC for packaging

Completely unplasticized polyvinyl sheet made by *Anorgana G.m.b.H.* is available in the United States through *David S. Greenfield,* 1489 Plimpton Ave., New York 52. Called Genotherm, it is odorless and tasteless. In Germany the material has been used for packing fish, cheese spreads, jams and other foods. In this country it has been used primarily in various kinds of tapes.

Easily vacuum molded, Genotherm is weldable, transparent and has good tensile strength. (See table for typical properties). Lack of plasticizer precludes the possibility of plasticizer migration. In spite of the unplasticized condition, the material is said to be relatively tough. Practically impervious to moisture, it is chemically stable and not affected by most organic and inorganic substances.

Aside from food packaging and tape, Genotherm has been used for cable insulators, linings, wall coverings, book binding, tubing, bags and squeeze tubes. It is flame resistant and can be bonded or laminated to paper, cardboard, wood, metal and concrete.

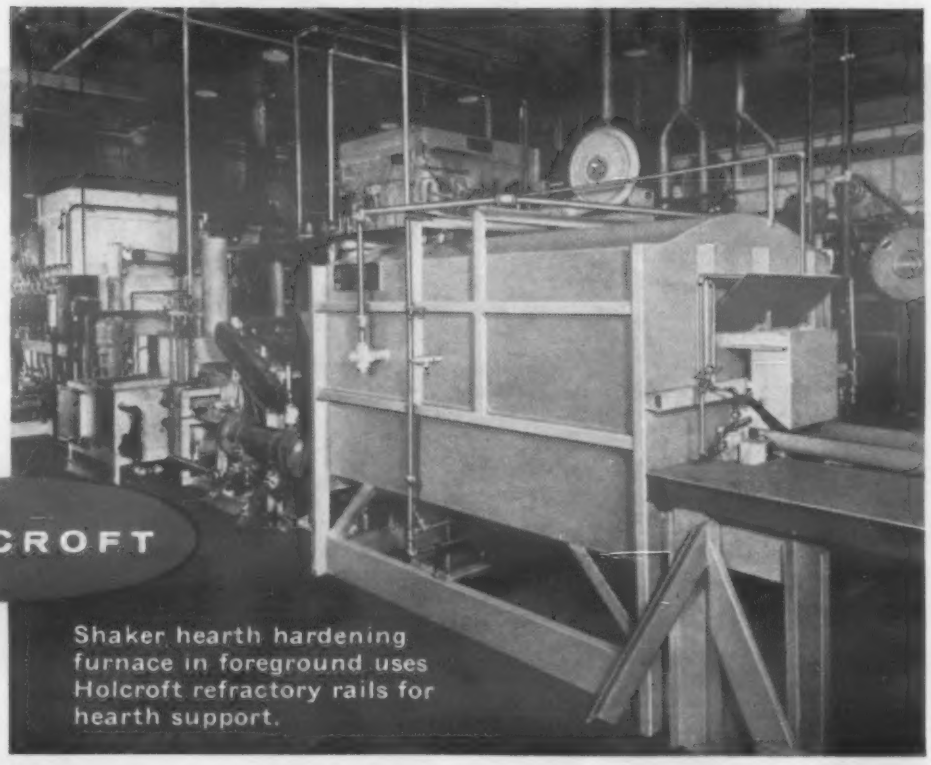
Genotherm is supplied in any color—transparent or opaque. It is made in two grades, oriented (G) and unoriented (UG). The G grade is characterized by high tensile strength and a tendency to shrink when heated above 175 F. The UG grade has a smooth uniform surface and is suitable for coating fiber board and hard paper.

Seamless PVC flat tubing made by the same concern is also available for packaging applications. Called Guttagena, it may be formed in a variety of shapes, can be preprinted or labeled, and

TYPICAL PROPERTIES OF GENOTHERM PVC SHEET

Property	Unoriented (UG)	Oriented (G)
Tensile Strength, psi		
Longitudinal	7800	8500-17,000
Transverse	7100	5600-7100
Elongation at Break, %		
Longitudinal	30-100	20-50
Transverse	10-30	10-20
Shrinkage (in 15 min at 212 F), %	2-5	40
Specific Gravity	1.38	
Modulus of Elasticity, psi	280,000	
Flexural Strength, psi	14,200	
Compressive Strength, psi	11,300	
Thermal Stability (Martens), F	149-158	
Flammability	Self-extinguishing	
Max Operating Temperature, F	122-140	
Internal Resistance, direct, megohms	10^{13}	
Surface Resistance, direct, megohms	10^{13}	
Corona Resistance	Good	
Dielectric Constant		
0.8 kc	3.4	
1000 kc	3.4	
Loss Factor		
0.8 kc	0.02	
1000 kc	0.015	
Water Absorption (7 da at 68F), mg/100 sq cm	<20	
Water Vapor Transmission Rate (65% against 20% relative humidity), gm/sq m/24 hr for foil thickness of:		
0.04 mm	4.5	
0.06 mm	3.1	
0.10 mm	1.8	
0.15 mm	1.5	
0.20 mm	1.0	
0.30 mm	0.8	

BLAZING THE HEAT TREAT TRAIL— WITH HOLCROFT



Shaker hearth hardening furnace in foreground uses Holcroft refractory rails for hearth support.

LET'S TALK ABOUT

REFRACTORY RAILS

With the current shortage of nickel, furnace manufacturers are looking for ways to replace or conserve this scarce commodity. It is interesting to note that Holcroft tackled this same problem during World War II when a nickel shortage also faced the industry.

In 1945 we designed and installed a pusher tray gas atmosphere furnace that used refractory skid rails instead of the nickel chrome alloys used at that time. Since then we have expanded their use to many other comparable applications so that now there is positive proof that properly designed installations of refractory skid rails last much longer, under similar conditions, than those made from nickel alloys. Replacements have been negligible—performance has been superior—material costs have been lower—and a marked decrease in wear on work carriers has been noted.

Yes, today a nickel shortage still exists—but Holcroft offers a job-proven answer, not only for the rails but for other vital parts of a heat treat furnace as well. You can bank on Holcroft's engineering leadership and experience—the kind that saves not only nickel—*but dollars, too!* Write for information.

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PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

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CANADA: Walker Metal Products, Ltd., Windsor, Ontario

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OTHER NEW MATERIALS PRODUCTS

can be heat sealed. It is unaffected by greases, acids and alkalies, and there is no migration problem. Items packed abroad include bleach, hair dye, shampoo and floor wax. The lightweight tubing is made in standard diameters from 10 to 50 mm and in wall thicknesses of 0.012 and 0.014 in.

2. Extruded sheets

The two new extruded sheets are being made by *Campco Div., Chicago Molded Products Corp.*, 2717 N. Normandy Ave., Chicago 35. They were previously made only by calendering. Typical properties are given in accompanying tables.

Extruded linear polyethylene sheet is available in both the Zeigler and Phillips types. Readily vacuum formed, the sheet is expected to find use in such products as containers, specially formed packages, trays and carboys. Because of its resistance to grease

PROPERTIES OF EXTRUDED LINEAR POLYETHYLENE SHEET

Property	Zeigler Type	Phillips Type
Spec Grav	0.945	0.96
Water Absorp in 24 hr, %	0.1	0.0
Heat Dist, 66 psi, F	140	168
Ten Str, psi	3200-3500	5100
Elong, %	300	—
Mod of Elast, 10^5 psi	0.64-1.0	—
Mod of Stiff in Flex, psi	75,000-125,000	140,000
Flex Str, psi	2200-2300	—
Notched Izod Impact Str, ft-lb	2.5-5.0	3.0
Rockwell Hardness	32-43R	—

PROPERTIES OF CAMPCO S-1029

Specific Gravity	1.01
Water Absorption in 24 hr, %	0.28
Heat Distortion, 66 F, psi	183
Tensile Strength, psi	4500
Elongation, %	100
Modulus of Elasticity, 10^5 psi	1.96
Flexural Strength, psi	6800
Notched Izod Impact Strength, ft-lb	
73 F	4.8
40 F	1.6
Rockwell Hardness	85R

..ask for a sample bar of La Salle's revolutionary

NEW fatigue-proof™ STEEL BAR

..the bar that has HIGH STRENGTH without heat treating

Yes, La Salle invites you to test a sample bar of the remarkable new FATIGUE-PROOF. This amazing new material is its own best recommendation . . . as proven by the many original equipment manufacturers who have already tested (and are using) FATIGUE-PROOF.

If you are making parts requiring strengths in the tensile range of 140,000 to 150,000 psi, and want to eliminate the expense or problems of heat treating . . . if you want to save production costs with a bar that machines faster (25% faster than annealed alloys—50% to 100% faster than heat treated alloys) and gives you a beautiful finish, too . . . if you want to improve the quality of your product while saving money, send us a blueprint, drop us a note giving application details, or better yet . . . pick up your telephone and call a La Salle sales engineer (REgent 4-7800, Chicago, Illinois).

If it appears that FATIGUE-PROOF can help you improve your product and cut your cost, he will arrange to provide the necessary test sample at no expense to you.

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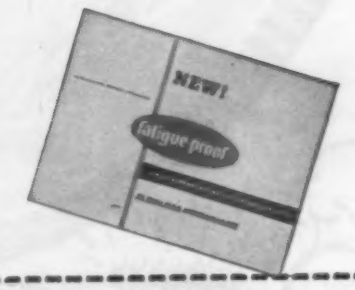

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A major development in small motor brushes

Stackpole Grade 373 fractional h.p. brushes show materially longer life coupled with minimum commutator wear. Ideally suited to cleaners, food mixers, sewing machines, calculators and similar motorized equipment, they are typical of progress achieved in Stackpole's continuing brush development program.

Brush headquarters for every type of rotating electrical equipment . . . backed by a half a century's specialized experience in developing and producing dependable carbon-graphite and metallic powder materials and components.

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Plants: St. Marys, Penna. (2) . . . . . Kane, Penna. (3) . . . . . Johnsonburg, Penna. . . . Canadian Stackpole, Toronto, Ont.

For more information, turn to Reader Service Card, Circle No. 438

OTHER NEW MATERIALS PRODUCTS

and acids and its improved heat distortion resistance, it may also be useful for hospital equipment, machine housings and housewares. The sheet is adaptable to complex shapes. Slight modifications in present heating equipment may be necessary to accommodate the material's different heating cycle and a tendency toward plastic memory.

Campco S-1029 is said to be the first copolymer styrene sheet successfully extruded. Previously, thick sections were formed by laminating calendered sheet with a resultant sacrifice of both strength and color. The extruded sheet is available in sizes up to 3/16 in. and in a wide range of colors. It can be readily vacuum formed and is expected to be useful for machine housings, tote boxes, luggage and various automotive applications, such as panels, liners and seat skirts.

Packaging Adhesive

An adhesive with a flexible plastic base makes it possible to bond polyethylene to chip and kraft board, as in making packaging envelopes and polyethylene laminated bags and boxes. Designated No. 3570 Polygriptex, it is available from *Adhesive Products Corp.*, 1660 Boone Ave., New York 60. The material is reported not to crystallize and to have good resistance and aging qualities.

Tool Steels Available in Extruded Shapes

Tool and high speed steels will now be available in a great variety of extruded shapes, according to *Allegheny Ludlum Steel Corp.*, Rm 2036, Henry W. Oliver Bldg., Pittsburgh 22. The newly developed hot extrusion process has been successfully applied to many of this company's standard line,

Thermal Resistance...Chemical Resistance!

Now Available!

- **DACRON***
- **ORLON†**
- **NYLON**
- **ARNEL®**
- **ACRILAN****
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Send today for fact sheets!

*DuPont trademark for its polyester fiber
†DuPont trademark for its acrylic fiber
**®Acrylic fiber by Chemstrand
††Union Carbide's acrylic fiber

Now, American, through its technical research, has perfected the mechanical interlocking of the man-made fibers listed at the left, to produce three-dimensional felt structures.

These new Felts by American have exceptional *chemical resistance* with *thermal stability* to 300 F. They are non-hygroscopic, biologically stable and are available in a complete range of thicknesses. Precision engineering assures close density and thickness control.

The properties which characterize these new Felts are being utilized in filtration—laminated plastics as reinforcing material—high temperature bearing seals—gasketing. In fact, end uses are unlimited!

American's engineering and research staff is prepared to supply you with complete data and product recommendations. Write today!

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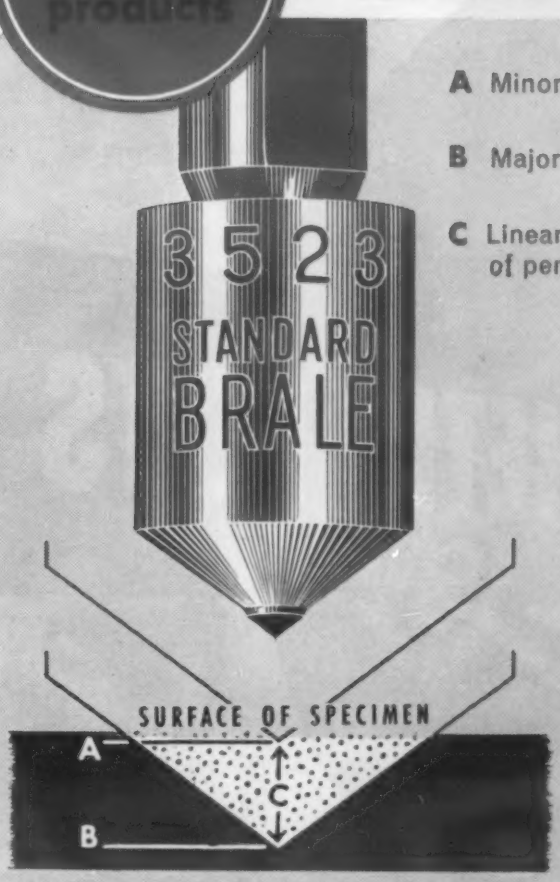
For more information, turn to Reader Service Card, Circle No. 400

Wilson Diamond "Brale"* Penetrators

ACCO products



A Minor load penetration

B Major load penetration

C Linear measurement of penetration increase

To be SURE of your ROCKWELL* hardness test use only a

WILSON "BRALE" Penetrator

• WILSON Diamond "Brale" Penetrators are precision ground under high magnification to assure mathematical and microscopic accuracy. Each is standardized on test blocks and rigidly inspected at the WILSON Standardizing Laboratory.

Because of this meticulous attention to manufacturing detail, WILSON Diamond "Brale" Penetrators provide the extreme accuracy demanded of an instrument where the difference between a single degree of "ROCKWELL" reading is but 0.00008" penetration.

Special "Brale" Penetrators are available for testing unique areas—the pitch line of gears, for instance, or high temperature testing. N "Brale" Penetrators are supplied for use with WILSON "ROCKWELL" Superficial Testers.

A WILSON *expert on hardness testing is never more than a few hours away. Prompt* WILSON *service guarantees top performance from* WILSON *equipment.*

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Fully automatic

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AMERICAN CHAIN & CABLE

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Yes, Better Value

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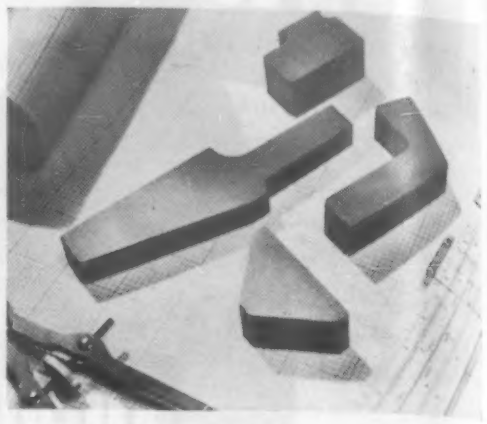
OTHER NEW MATERIALS PRODUCTS



***Cross sections** of extruded tool shapes show wide variety.*

thereby bringing the design and operating flexibility of the extrusion process to materials that could not previously be extruded.

Hot extruded tool steel products are limited in maximum size to sections that can be inscribed in a 4-in. dia circle and are at least ½ sq in. in cross sectional area. Tubular products are available as well as shapes. Maximum product length in the unannealed condition is 40 ft and in the annealed condition is 12 ft. Hot rolled tolerances are generally held. The hot worked extruded structure has been found to be similar to that of rolled material. Little decarburization has been found.

Porous Metal Sheet Made by Perforation

The permeability in a new porous metal sheet is controlled by distributed perforations. Called Varaperf, it is manufactured by *BLC Porous Materials Co., Div. of Engineered Fabrications, Inc.*, 1955 Lafayette St., Santa Clara, Calif. It is made in a range of permeability to cover all applications of boundary layer control for high lift, drag reduction or transpiration cooling.

Flow capacity is predictable and reproducible as a result of precise control of hole size and pattern. Perforation patterns can be tailored to meet any suction or injection flow distribution with either

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FOR ALL HEAT-DEPENDENT OPERATIONS

looks like a crayon...

marks like a crayon...

tells temperatures like a precision instrument!

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TEMPILSTIK° marks on workpiece "say when" by melting at stated temperatures—plus or minus 1%.

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How Tempilstiks° are used

● TEMPILSTIKS° are temperature-sensitive crayons of calibrated melting points. There are some sixty-five different TEMPILSTIKS° in the range from 113°F to 2000°F, each indicating a specified temperature, within a tolerance of plus or minus 1% of its rating.

The appropriate TEMPILSTIK° is selected and, for most applications, the work-piece is marked with it before heat is applied. On subsequent heating the crayon-like mark of the TEMPILSTIK° melts as soon as its temperature rating is reached.

The mark made by a TEMPILSTIK° may gradually change in color as heating progresses. The change in color, or in color intensity, is never to be interpreted as a temperature indication. The TEMPILSTIK° mark melts when its temperature rating is reached and only this change from the dry to the liquid condition is the significant temperature signal.

In some applications this simple method may not suffice because evaporation of the TEMPILSTIK° mark on prolonged heating, or its gradual absorption by the surface at high temperatures, may leave too little residual substance for unambiguous observation. In such cases stroking or touching the work-piece with the TEMPILSTIK° at regular intervals during the heating process is recommended. The TEMPILSTIK° will leave a dry mark at temperatures below its rating and a liquid streak when its temperature rating has been reached or exceeded. If the workpiece is not accessible for applying a TEMPILSTIK° during the heating process, then TEMPILAQ°, or possibly TEMPIL° PELLETS, should be used instead.

TEMPILSTIKS° will usually glide over unheated polished surfaces (like glass, polished stainless steel, etc.) without leaving an appreciable mark. Therefore, in applications that involve smooth or polished surfaces TEMPILSTIKS° should be used by touching or stroking the workpiece periodically during the heating process, as previously described, because a liquid streak will be made on contact as soon as the specified temperature is reached. Where it is necessary to mark a smooth work piece surface prior to heating, TEMPILAQ° should be used.

A hot radiating surface will appear relatively dark under intense illumination from an external source, and this fact can be utilized to improve recognition of the temperature signal against a red-hot background. The use of TEMPIL° PELLETS or TEMPILAQ° instead of TEMPILSTIKS° will further improve visibility under these conditions.

On rapidly moving objects, like magnesium or aluminum sheet during spinning operations, it is impossible to see whether the applied TEMPILSTIK° leaves a dry or melted mark. However, with a little experience operators quickly learn to sense the smooth gliding of a TEMPILSTIK° over a surface which is hot enough to melt it on contact, as contrasted to the frictional drag on a cooler surface. If the top of the TEMPILSTIK° is brought in contact with the moving metal surface for a brief moment at a time, and with light pressure only, the heat contribution of friction is trivial enough to be ignored.

The above described "sensing technique" may also be employed on hot radiating surfaces where the bright background makes it difficult to distinguish whether or not the TEMPILSTIK° mark had melted.

An appropriate series of TEMPILSTIK° marks, applied to the workpiece or surface under investigation before heating begins, will provide a record of the maximum temperature attained during a process or operation. Subsequent examination will show that all TEMPILSTIK° marks up to a certain temperature rating had melted, while those of a higher rating had not. The maximum attained temperature must consequently lie somewhere in the interval between the highest melted and the lowest unmelted TEMPILSTIK° rating.

The temperature distribution and isothermal boundaries of surfaces such as furnace walls, melting ladles, cement kilns, etc., can be established by using an appropriately chosen series of TEMPILSTIKS° to draw a pattern of lines (parallel, concentric, radial, etc.) on the area under investigation. The heat conduction along a surface can be effectively studied by the progressive melting of suitably chosen TEMPILSTIK° lines. Caution must be exercised not to permit the mark made with one TEMPILSTIK° rating to cross or overlap the mark of a dissimilar TEMPILSTIK°, as such a mixing of different TEMPILSTIK° marks would destroy their accuracy.

TEMPIL° products will give good results in induction heating and in ionized air, as well as in the presence of static electricity about electrical equipment, where electrical means of measuring temperatures often function erratically.

Visit us at Booth 116 Sept. 17-21 Instrument-Automation Exhibit—N. Y. Coliseum
Visit us at Booth 929 Oct. 8-12 National Metal Congress—Cleveland

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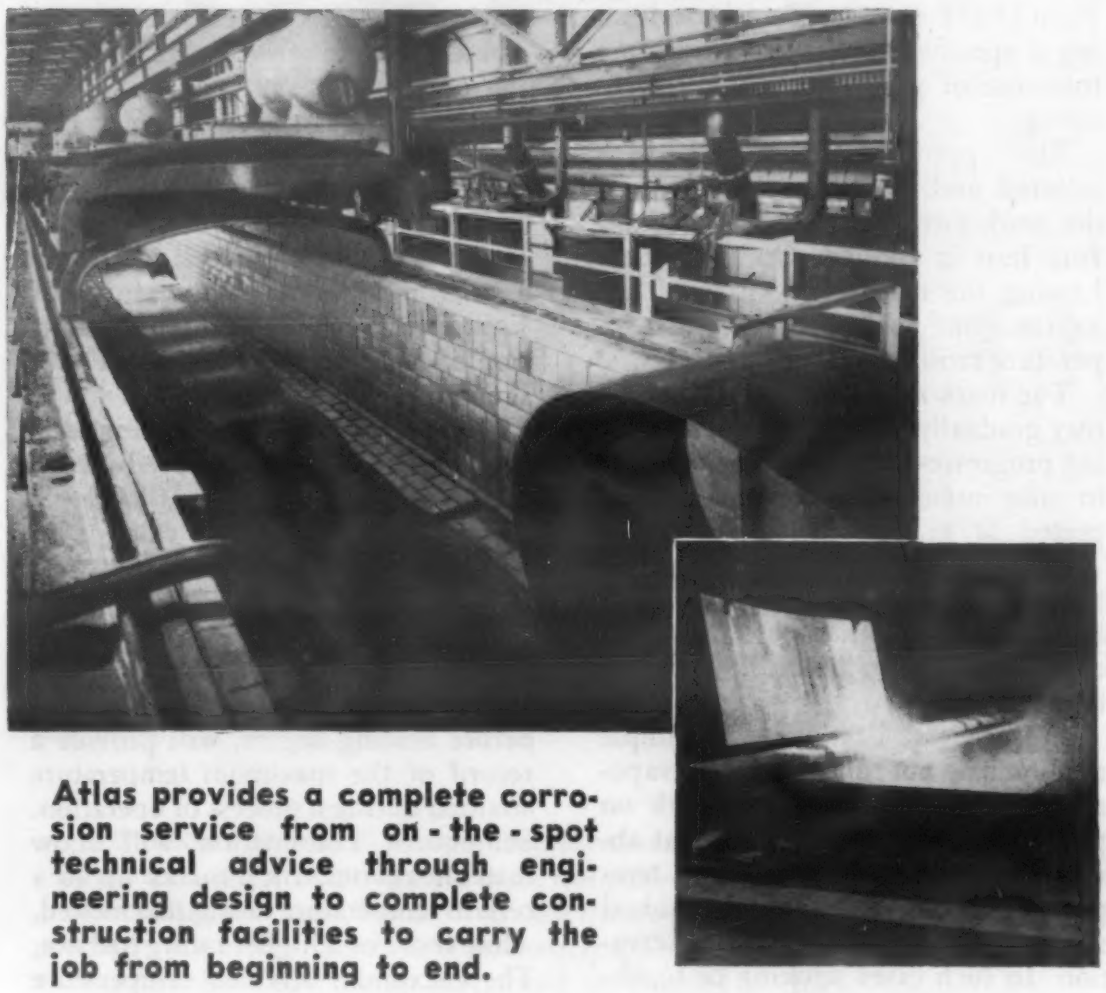
ATLAS PICKLING TANKS
in service to stay



Atlas provides a complete corrosion service from on-the-spot technical advice through engineering design to complete construction facilities to carry the job from beginning to end.

When you install pickling tanks, you have a right to expect them to deliver service in full measure. You can't get it if these units are the cause of lost production due to down time for repair of corrosion damage.

Pickling tanks of Atlas construction reduce down time to a minimum, because Atlas cements, coatings and linings are designed to handle the rugged abuse of modern pickling.

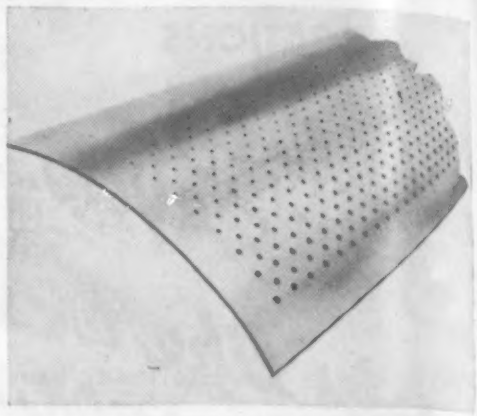
For a quarter century Atlas has been producing Corrosion-Resistant materials of construction for industry-wide use in combatting corrosion. Atlas, with the advance of technical knowledge, has developed new materials and improved existing products to keep pace with the increasing use of strong pickling agents and higher processing temperatures.

Now Atlas can offer the most complete line of quality corrosion-proof materials available. Your pickling tanks will become a permanent asset when you make sure that ATLAS CORROSION-PROOF CEMENTS, COATINGS, and LININGS are specified.

Write for your copy of Atlas Bulletin CC#3 containing informative data on the complete Atlas line.

ATLAS MINERAL PRODUCTS COMPANY
MERTZTOWN, PENNSYLVANIA

OTHER NEW MATERIALS PRODUCTS



***Porous sheet** of high strength metals is readily formed to contour.*

uniform or gradient pressure-drop characteristics. Varaperf is claimed to be nonclogging in practical operation.

Porous sheets can be made from aluminum or other high strength metals. They are readily formed to contour. Made in sizes and gages for aircraft, missile and laboratory use, Varaperf is easily attached by conventional methods.

Low Toxic Hardeners for Epoxy Tooling

Two new water repellent hardeners of low toxicity for use with Epocast epoxy tooling plastics are available from *Furane Plastics, Inc.*, 4516 Brazil St., Los Angeles 39. Both hardeners were found to be nondermatitic when tested by the patch test method on male and female personnel for a two-week period.

Hardener 946 has a pot life of 10 to 15 min at ambient room temperature. Hardener 986, under the same conditions, has a pot life of 25 to 30 min.

Recent Cleaners, Finishing Materials

An improved cold cleaner, an electrolytic salt for cleaning gray iron castings, and a new alkaline barrel finishing compound are among recent developments. These

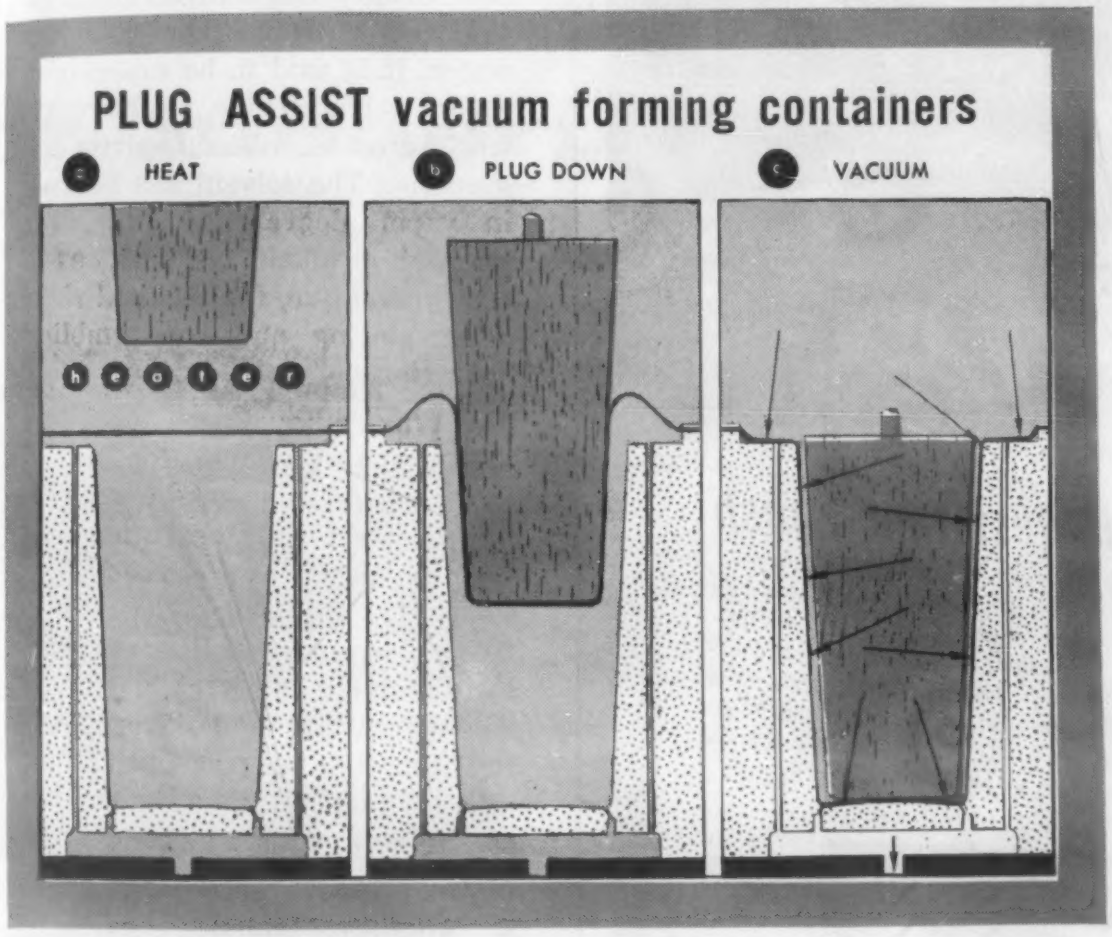
For more information, turn to Reader Service Card, Circle No. 545

DOW

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

"PLUG ASSIST" TECHNIQUE OFFERS NEW ADVANTAGES IN VACUUM FORMING



Increased flexibility in forming offers designers opportunities to make important new uses of plastic sheet

This improved fabrication method for polystyrene sheet products, developed by The Dow Chemical Company and called the plug assist technique, opens new horizons for the progressive designer. With more uniform wall thickness and more even distribution of material in deep-drawn, vacuum-formed parts, plastic sheet applications are increased many times. The added flexibility in design is made possible by a force plug which pre-forms the heated sheet in the cavity prior to drawing the vacuum.

Thorough plastiatrics research is continuously directed toward practical solutions such as demanded for the problem in forming sheet. Shearing or scoring is prevented by the slight air pressure produced between the sheet and the cavity until the plug stops traveling and the vacuum is drawn. The process has been thoroughly tested and appears to lend itself to high-speed automatic forming operations.

The plug assist method is only one of many contributions made by Dow Plastiatrics to every phase of formulation, design and molding for the plastics' industry.

SHEET AVAILABLE FROM MANY EXTRUDERS

In 1952, Dow introduced a method for extrusion of Styron® plastic high-impact sheet. Today, more than thirty extruders offer high-quality, uniform sheet products based on Styron plastic materials. Their names, and the names of qualified fabricators, will be gladly furnished by our nearest Dow Sales Office.

TECHNICAL LITERATURE OFFERED

Several technical bulletins are available at no cost for more detailed information on Styron high-impact plastic sheet for vacuum forming, pressure forming, stamping and embossing. Whatever your problem you may consult Dow with assurance of prompt, confidential help and advice. Write, on your letterhead, to THE DOW CHEMICAL COMPANY, Midland, Mich.—Plastics Sales Dept. PL 435H.

AMERICA'S FIRST FAMILY OF POLYSTYRENES

GENERAL PURPOSE
- STYRON 666
- STYRON 665 (Extrusion)
- STYRON 688 (Easy Flow)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 429 (Extrusion)
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

you can depend on DOW PLASTICS

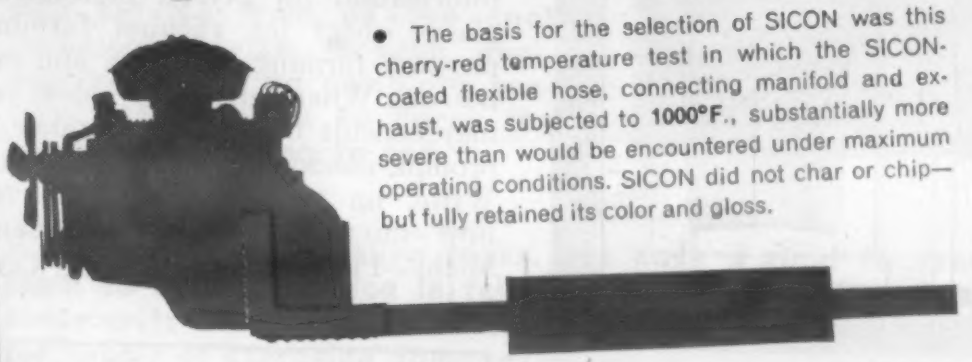
DOW

For more information, turn to Reader Service Card, Circle No. 557

"Wrought from the finest materials in the world"

CONTINENTAL MARK II

Example: **SICON® Heat Resistant Finish**



● The basis for the selection of SICON was this cherry-red temperature test in which the SICON-coated flexible hose, connecting manifold and exhaust, was subjected to **1000°F.**, substantially more severe than would be encountered under maximum operating conditions. SICON did not char or chip—but fully retained its color and gloss.

● Only the finest in materials are good enough for the magnificent Continental Mark II. SICON not only resists high temperatures on the flexible hose connection—where the movable segments would quickly chip ordinary finishes—but also retains its rich color and gloss to assure fine appearance.

Wherever there is high temperature, wherever product *appearance* is as important as *protection* you need the tough film adhesion of SICON. You can specify SICON in black, aluminum—even in smart decorative colors. Write for SICON literature . . . today.

Sicon®

The Original Silicone Heat Resistant Finish

MIDLAND *Industrial Finishes Co.* Waukegan, Ill. Dept. I-1

ENAMELS • SYNTHETICS • LACQUERS • VARNISHES

For more information, turn to Reader Service Card, Circle No. 433

OTHER NEW MATERIALS PRODUCTS

and other similar products are described below.

1. Nonflammable solvent

A nontoxic, nonflammable solvent is claimed to clean, degrease and rustproof all metal surfaces safely and effectively in one operation. Called Immunol, it is available from *Harry Miller Corp.*, 4th and Bristol St., Philadelphia 40.

Mixed with hot or cold tap water, it is said to be superior to carbon tetrachloride, trichlorethylene, kerosene, mineral spirits and gasoline. The solvent can be used in vapor degreasing units, for improving alkali cleaners, as a rust preventive, for the final rinse after plating and for tumbling operations.

2. Wax remover

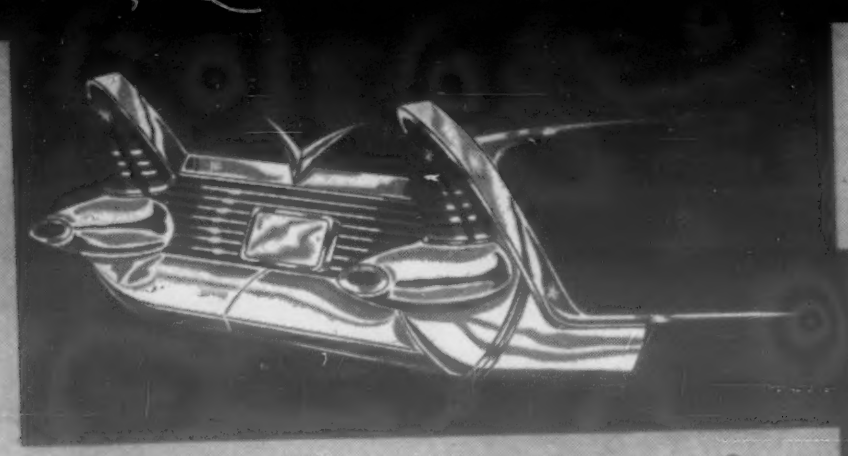
A prepaint cleaner for removing wax and silicones on automobile bodies before repainting has been developed by *Permacel Tape Corp.*, New Brunswick, N.J. Designated Permacel 340 Bite, it cleans by dissolving oil, grease, gummy substances, wax and silicones. At the same time the prepaint cleaner microscopically etches the surface so the new paint will bond properly.

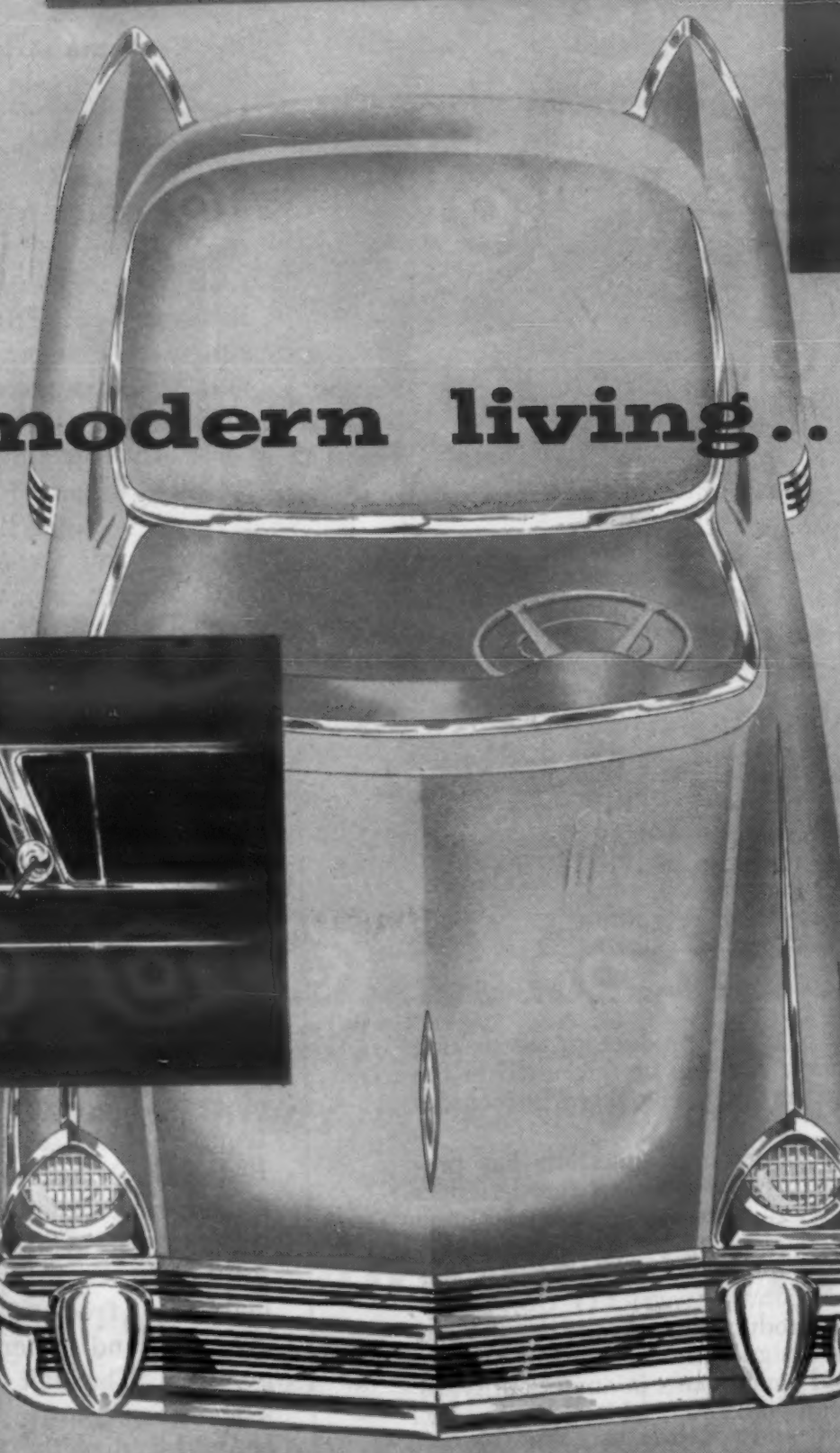
3. Alkaline cleaner

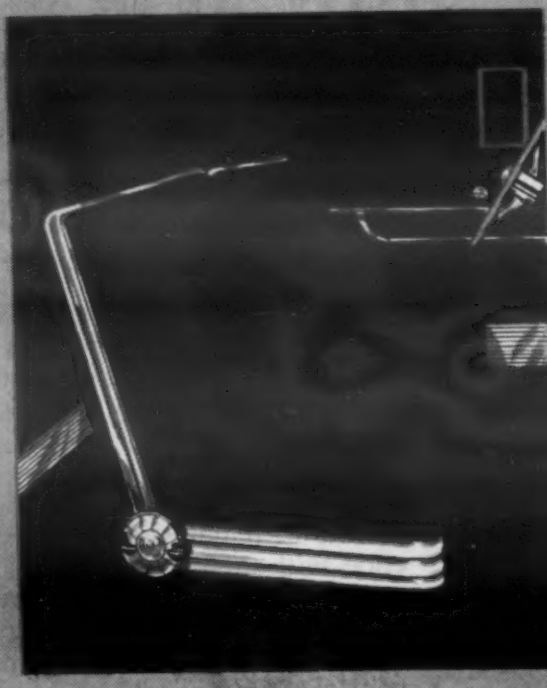
A nonflammable, alkaline material for the removal of rust, paint and primer in one dip and rinse operation has been developed by *Turco Products, Inc.*, 6135 S. Central Ave., Los Angeles 1. Called Turco Alkaline Rust Remover, the powdered compound is said to eliminate many steps required for rust and paint removal by conventional methods.

An aqueous solution of the compound is claimed to remove light rust in less than 1 min. Heavy rust and multiple paint layers usually require 10 to 20 min immersion. Red oxide primer, baked lacquer, acid-proof paint and asphalt finishes also yield to the remover. It contains no cyanide compounds and will not affect dimensional tolerances or cause hydrogen embrittlement. It re-

For more information, Circle No. 418 >







or modern living... *the style is Stainless!*

A rich, lustrous and, above all, serviceable metal that denotes quality at its finest . . . that's Sharon Stainless Steel.

Nothing looks so well so long as stainless steel, but, more important, modern living standards demand a metal that will resist denting, corrosion, road abrasion and pitting. Stainless is beauty all the way through. It's not a softy with a thin skin.

This maximum utility plus excellence of finish and consistent uniformity, coil after coil, have been big reasons why Sharon has remained a leading supplier of stainless steel to the automotive industry since the very beginning.

SHARON *Stainless Steel*

SHARON STEEL CORPORATION *Sharon, Pennsylvania*

DISTRICT SALES OFFICES: Chicago, Cincinnati, Cleveland, Dayton, Detroit, Grand Rapids, Indianapolis, Los Angeles, Milwaukee, New York, Philadelphia, Rochester, San Francisco, Sharon, Seattle, Montreal, Que., Toronto, Ont.

9907

ARE WE IN YOUR FILES?

AS A DEPENDABLE SOURCE FOR MAGNESIUM PARTS AND PRODUCTS

Whether you plan the development of a new product, or are seeking ways to further improve existing ones, you will be interested in the many new avenues which are open to the design engineer who includes magnesium in his basic planning.

Magline Inc.—one of America's leaders in magnesium—has prepared a descriptive new bulletin, expressly outlining for designers and engineers, the company's services as a reliable, experienced source for magnesium castings, fabrication and complete production. Specialists in magnesium exclusively, Magline's background and experience will serve you well in three important ways: (1) Objectively searching out ways to improve your product through the application of magnesium; (2) Assisting in the design and development phases; (3) Producing the required parts and components in any quantity, to your exact specifications. May we send you a copy of Bulletin No. 50.

MagLine

fabrication facilities for

- Forming
- Machining
- Welding
- Stamping
- Spinning
- Deep Drawing
- Polishing
- Finishing
- Stress Relieving
- Assembly
- Impact Extruding

foundry facilities for

- Sand Castings
- Die Castings
- Permanent Molds

Design and Engineering Services Available

WRITE TODAY FOR BULLETIN NO. 50. MAGLINE, INC., BOX 419, PINCONNING, MICHIGAN.
CANADIAN FACTORY: MAGLINE OF CANADA, LIMITED, RENFREW, ONTARIO.

For more information, turn to Reader Service Card, Circle No. 421

OTHER NEW MATERIALS PRODUCTS

quires no neutralization, only a pressure rinse.

4. Urethane stripper

A noncorrosive solvent type stripper has been developed to remove polyurethane reaction products from ferrous and nonferrous metals. Called Isothane polyurethane stripper, it is available from *Surface Chemicals, Inc.*, 1006 Liberty Ave., Pittsburgh 22. A simple solvent wash after stripping will give recoatable surfaces. It may be applied by dip, flow coat, brush or spray.

5. Cold cleaner

A cold cleaner that removes all types of soil including cosmoline rustproofing compounds has been developed by *Klem Chemicals, Inc.*, 14401 Lanson Ave., Dearborn, Mich. The one-package product, called Klem Kleaner No. 258, is made ready to use simply by adding 1½ to 3 oz to a gallon of water. Parts cleaned with it are reported to remain free of rust for three to four months. Foaming, a major problem with many cold cleaners, is claimed to be controlled.

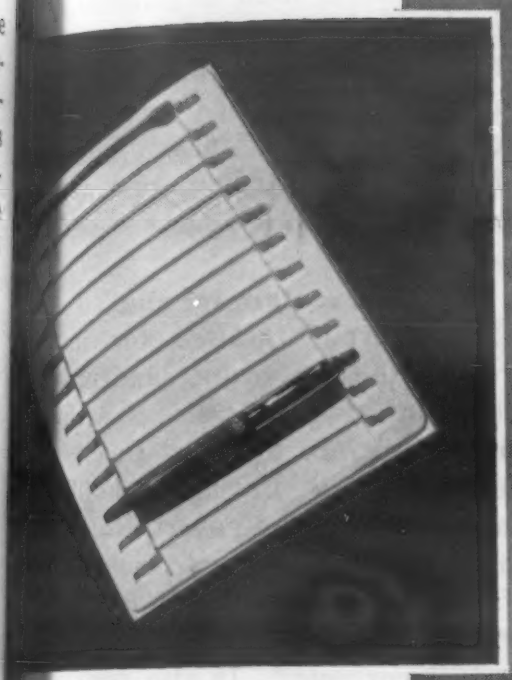
6. Molten salt cleaner

A salt for electrolytic cleaning of gray iron castings is available from *Hooker Electrochemical Co.*, Box 344, Niagara Falls, N. Y. Called Virgo Electrolytic Salt, it contains an additive that leaves gray iron castings and related materials free of sand, scale, graphite and other surface impurities. The salt is compatible with other known salts and can be added directly to electrolytic baths. It is used in cleaning processes involving a molten bath operated in the 900 F range, followed by a cold water quench and a hot rinse.

7. Barrel finishing compound

An alkaline material for barrel deburring of small parts is available from *Oakite Products, Inc.*, 132H Rector St., New York 6. The compound combines a fine, fast cutting abrasive with surface

For more information, Circle No. 441



TRY A Parker Jotter NOW!
Out-performs and out-lasts any other Ball Point Pen! $2.95
Exclusive Jotter refill out-lasts 5 ordinary refills!

A sheet of BAKELITE Brand Impact Styrene, formed to fit 12 PARKER Jotters, holds these ball-point pens firmly in the package and on display. It was formed by **Janesville Paper Box Co.**, Janesville, Wis., from sheets extruded by Midwest Plastic Products, Chicago, Ill.

Vacuum-formed impact styrene sheets provide

"write your own ticket" latitude

This tray has grooves vacuum-formed to such a precise fit that they hold each pen firmly in place. It keeps the pens safe in shipment. And for display, the tray is quickly slipped into the display case. The pens stay neatly in order. The sheet of BAKELITE Brand Impact Styrene—white, smooth, and easy to clean—sets off the colored pen barrels.

The variety of products vacuum-formed from extruded sheets of BAKELITE Brand Impact Styrene ranges from the small trays illustrated to large refrigerator door liners. They all possess the same advantages—toughness, excellent appearance, accurately formed details.

Vacuum-forming is growing fast because of its speed and economy. BAKELITE Impact Styrene is ideally suited to this process because it can be extruded into sheets that keep their gloss and toughness after forming. The products that result have excellent impact resistance plus good finish. Their color range is practically unlimited.

You can investigate the possibilities of vacuum-forming BAKELITE Impact Styrene for your own product with the aid of qualified Bakelite Company technical representatives. Write Dept. SU-108.

BAKELITE BRAND PLASTICS

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

Introducing

Bakekote

Another NICKELOID First!

Here's what Bakekote is

Bakekote is the Nickeloid family trademark for a revolutionary new *baked synthetic* protective coating for Nickeloid pre-finished metals, in copper and brass finishes. It contains one of the newest thermosetting resins with film properties far superior to regular lacquer and most other synthetics on the market: maximum gloss, hardness, adhesion, flexibility, chemical resistance, abrasion resistance. The clear Bakekote film is applied to Nickeloid Metals by spray or pressure, then *baked and cured* (not just air-dried) with intense heat. *There is no comparable product on the market today.*

RIGIDLY TESTED and PROVEN

Flexibility | Excellent Adherence | No Peeling

A stamped pan, severely drawn shows no evidence of lifting or cracking.

A canister lid, stamped without a draw ring, has perfect adherence even on the wrinkled flange.

Seamed canister bodies are formed with no lifting or peeling of the Bakekote film.

Greater Salt Spray Resistance

Actual photo of results from 48 hr. salt spray test on pre-plated Copper Steel shows Bakekote (right) provides 80% to 90% better resistance than regular lacquer finish (left).

where you can use Bakekote

A tough, adherent, elastic film, Bakekote coated metal can be drawn, press formed, stamped, roll formed and seamed with no fear that the coating will peel, crack or flake. It's the ideal *protected* copper or brass finish for door hardware, switch plates, knob inlays, light fixtures, bezel plates, housewares.

Write for Details

NICKELOID METALS
SINCE 1898

AMERICAN NICKELOID COMPANY

PERU 6, ILLINOIS

For more information, turn to Reader Service Card, Circle No. 541

active agents that keep the media bright and sharp. Called Oakite FM 183, it is used in concentrations of 1 to 5 oz per gal of water. The compound is designed for deburring stamped or machined parts, grinding off sharp edges, and removing tarnish, rust and heat scale. It also improves surface finish.

8. Chrome sealers for zinc

Two chrome sealers for improving the appearance and protection of zinc die castings without plating are made by *Conversion Chemical Corp.*, Rockville, Conn. They are Kenvert No. 50 and No. 51. According to the manufacturer, Kenvert No. 50 insures bright, clear finishes and protects against corrosion. It also resists fingerprinting and staining. By varying the cycle or concentration of the solution, a bright iridescent or a golden brown color can be produced.

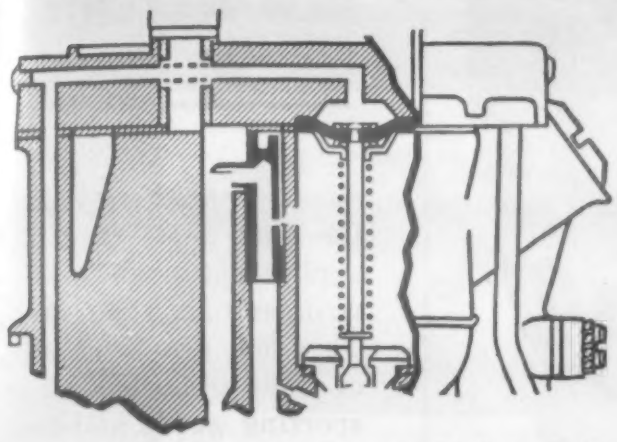
Kenvert 51 is recommended when a greenish gray to olive drab film is desired. This coating can be produced in a highly stable bath that is uniformly reproducible. Kenvert No. 51 offers good corrosion protection and, like No. 50, is a good base for paint.

Styrene Rubber Properties Improved

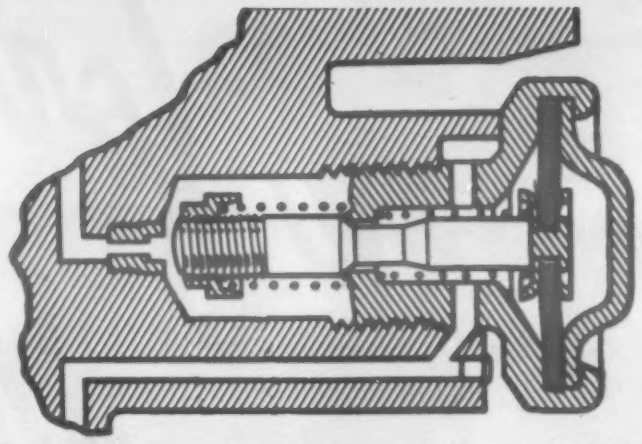
Uniformity, processing and color have been improved in three styrene rubbers developed by the *Chemical Div., Goodyear Tire & Rubber Co.*, Akron 16, Ohio. Two of the rubbers, Plioflex 1773 and 1778, are new. The third rubber, Plioflex 1006, a hot, nonextended styrene, is now lighter in color.

Plioflex 1773 is a cold oil masterbatch with 25 parts naphthenic oil. Plioflex 1778, also a cold oil masterbatch, contains 37.5 parts naphthenic oil.

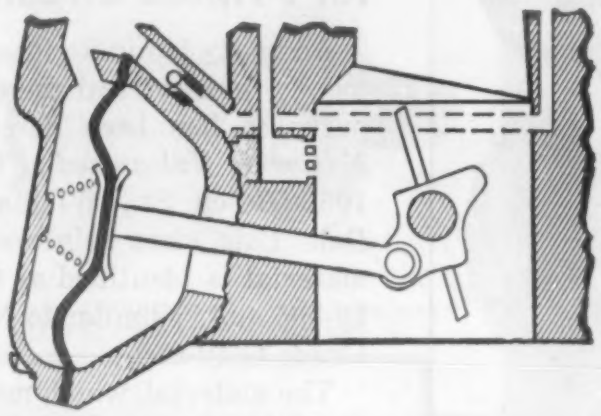
All three elastomers have nonstaining, nondiscoloring proper-



Economizer diaphragm (shown in red) functions automatically to control the correct amount of fuel for the fuel-air mixture. Du Pont "Fairprene" diaphragm resists aging—remains sensitive even in the presence of gasoline vapors at engine operating temperatures.



The acceleration pump diaphragm (shown in red) prevents backfiring or slowdown during sudden acceleration. Diaphragm must withstand severe flexing in the presence of gasoline vapor. "Fairprene" withstands this service with no flex cracking or deterioration.



Secondary throttle diaphragm (shown in red) regulates fuel on the four-barrel carburetor. This diaphragm must be sensitive and resist permanent set and drift. Dependable performance of Du Pont "Fairprene" helps explain the successful operation of the Holley carburetor.

For maximum efficiency Holley carburetors are diaphragm- rather than piston-operated. Precise control under severe operating conditions is assured by use of diaphragms of Du Pont "Fairprene."

Designers at Holley Carburetor Co. find...

Diaphragms of Du Pont "Fairprene"® assure lasting resistance to fuel and flex cracking

DU PONT INDUSTRIAL COATED FABRICS

COATING MEDIUMS

Neoprene • Buna-N • Silicone • Polyacrylate
Chlorosulfonated Polyethylene • Tetrafluoroethylene
Butyl • Acrylic • Polyamide
Polyethylene • Polysulfide

SUBSTRATES

Fabrics	Felts or Non-Woven
Cotton . Nylon . "Dacron"*	"Teflon" Felts
"Orlon"** . Asbestos . Glass	Wool Felts
Metal . Rayon . "Teflon"***	

Also elastomer sheet stocks without fabric inserts and cements

**"Dacron" is Du Pont's registered trademark for its polyester fiber*
***"Orlon" is Du Pont's registered trademark for its acrylic fiber*
****"Teflon" is Du Pont's trademark for its tetrafluoroethylene fiber*

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Holley Carburetor Company must have reliable performance from their diaphragm-operated carburetors. That's why they specified Du Pont "Fairprene" coated fabrics for the diaphragm parts. Holley requirements for diaphragms of "Fairprene" were sensitivity, resistance to gasoline and fuel additives, flex resistance and long life. Du Pont "Fairprene" proved to be just right for the job.

This is just one application in which Du Pont "Fairprene" has proved its effectiveness. Used in diaphragms, gaskets, washers, packings, insulating pads, sealing tape or tarpaulins, "Fairprene" shows exceptional resistance to deterioration. Oils, greases, solvents, chemicals, abrasion and flexing in extremes of temperatures from -60°F. to 200°F. do not affect its performance or reduce its long life. It may pay you to investigate possible uses of Du Pont "Fairprene" coated fabrics in your product. For more information and technical data on uses of Du Pont "Fairprene" fill out and mail the coupon. It's free—mail the coupon today.

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, Dept. MM69, Wilmington 98, Delaware
Please send me your bulletin on technical data and uses of Du Pont "Fairprene" coated fabrics.

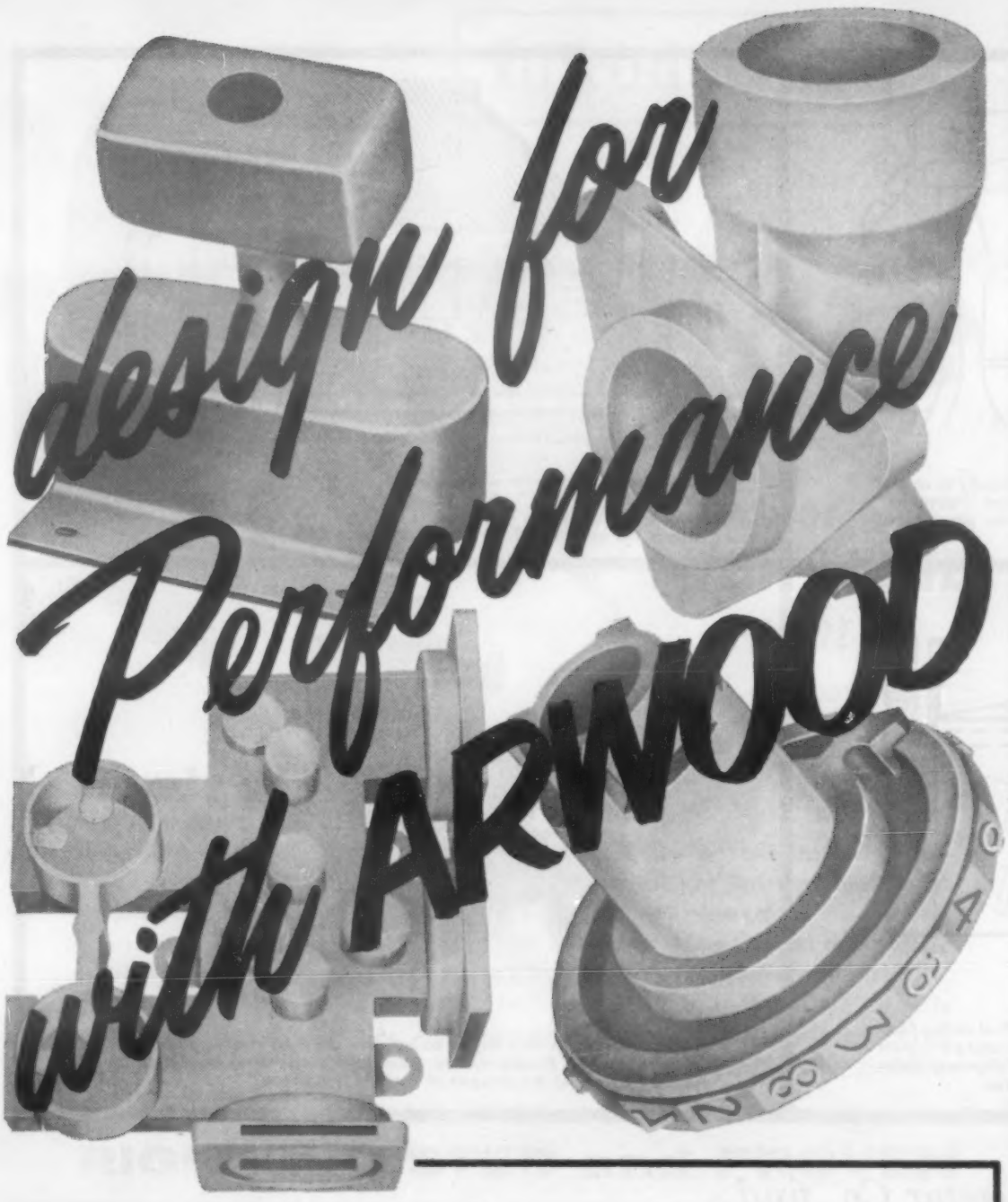
Name _____ Position _____

Company _____

Address _____

City _____ State _____

For more information, turn to Reader Service Card, Circle No. 499



ARWOOD Investment Casting may be the answer to your design problems when ferrous or non-ferrous parts or components must be of intricate shape and unusual contour, of metals difficult or impossible to machine.

Problems like configuration, alloy selection, tolerances, surface finish and inspection standards affect production cost and performance. Choose wisely . . . Choose ARWOOD for design assistance and production efficiency.

For complete information on Precision Investment Casting, write TODAY.

ARWOOD

ARWOOD PRECISION CASTING CORP.
317 West 44th Street, New York 36, N. Y.
PLANTS: Brooklyn, N. Y.—Groton, Conn.—Tilton, N. H.—Los Angeles, Calif.
"PIONEERS IN INVESTMENT CASTING"

For more information, turn to Reader Service Card, Circle No. 575

ties that make them suitable for application in white sidewall tires, wringer rolls, shoe soles and heels. They may also be used in a variety of other products such as floor tile, sporting goods and toys.

Epoxy Laminate for Printed Circuits

An epoxy laminate intended primarily for electrical and electronic purposes has been developed by *National Vulcanized Fibre Co.*, 1056 Beech St., Wilmington 99, Del. This glass reinforced epoxy material is identified as Grade G-10-865 and is similar to National's Grade G-10-860.

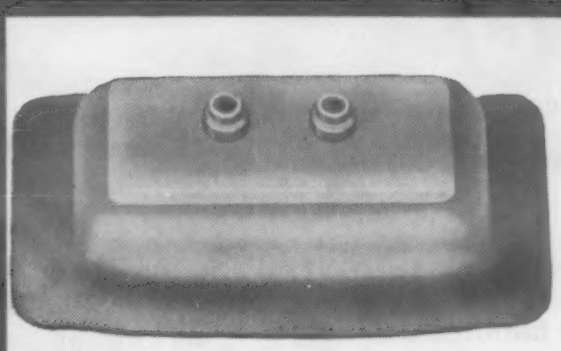
The material, which meets MIL-P-18177, has a low dissipation factor and high bond strength. Due to low water absorption, it has high insulation resistance and low dimensional stability.

The epoxy laminate is made in sheet sizes of 39 x 47 in. with

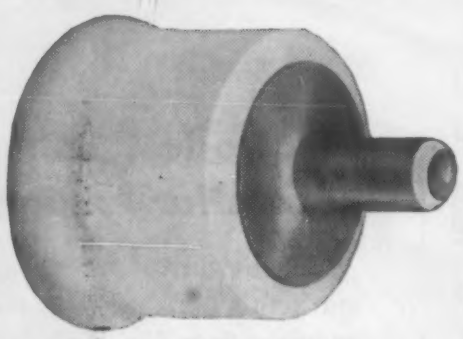
PROPERTIES OF G-10-865

Flexural Strength (flatwise), psi	
Cut lengthwise, ⅛ in. thk	72,000
Cut crosswise, ⅛ in. thk	63,800
Impact Strength, (edgewise, cond. E-48/50) ft-lb/in.	
Cut lengthwise, ⅛ in. thk	14.4
Cut crosswise, ⅛ in. thk	10.6
Water Absorption (cond. E-1/105, D-24/23, ⅛ in. thk), %	0.06
Bond Strength (cond. A, ½ in. thk), lb	2500
Dissipation Factor, (1 mc, cond. A, ⅛ in. thk)	0.0119
Dielectric Constant (1 mc, cond. A)	4.80
Dielectric Strength (parallel to laminations cond. A, 1/16 in. thk), kv	55
Dielectric Strength (perpendicular to laminations in oil, cond. A, 1/16 in. thk), v/mil	810
Arc Resistance (cond. A), sec	17
Insulation Resistance (cond. A), megohms	1,000,000
Volume Resistance (cond. C-96/35/90), megohm-cm	58,500,000
Surface Resistance (cond. C-96/35/90), megohms	900,000
Density	1.78

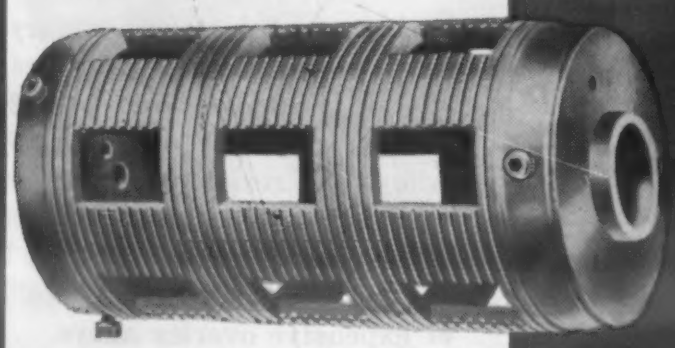
For more information, Circle No. 532



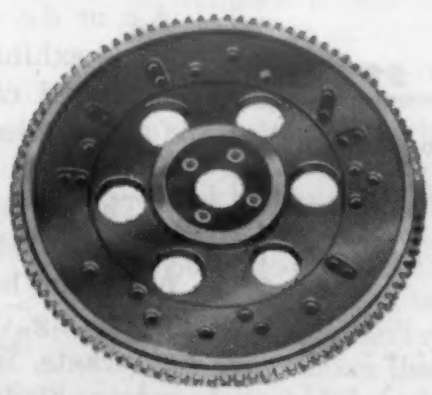
APPLIANCE SEAL . . . insures absolute physical seal — permanent bonding to inserts



BRUSH HOLDER STUD . . . maintains correct gapping under extreme conditions



COIL FORM . . . achieves dependable high speed, high frequency performance



SPUR GEAR . . . matching thermal expansion eliminates distortion and corona

. . . Moldable

SUPRAMICA® 555

VERSATILE CERAMOPLASTIC

. . . MAKES COMPLEX INSULATED PARTS — BETTER!

SUPRAMICA® 555 ceramoplastic offers an unbeatable combination of properties . . . absolute dimensional stability, high thermal endurance, every desirable electrical characteristic . . . plus precision moldability to permanent tolerances of ± .001".

Think how your projects can be improved by this unique ceramoplastic's ability to hold fragile inserts . . . expansion coefficient that matches steel . . . and distortion-free performance under widely varying conditions. Here's a single material with all the features you need . . . extremely low electrical loss . . . unexcelled arc resistance . . . complete freedom from carbonization and imperviousness to radiation effects, water, oil and organic solvents.

The secret of this superiority: SUPRAMICA 555 ceramoplastic's exclusive formulation of top grade electrical glass and SYNTHAMICA® synthetic mica. Send to Department 336 for an Engineering Data File on SUPRAMICA 555 ceramoplastic insulation and MYCALEX custom molding services.

SUPRAMICA® 555

MYCALEX

CORPORATION OF AMERICA

THE FIRST SUPRAMICA® CERAMOPLASTIC

SINCE 1919 MYCALEX® THE INSULATOR

GENERAL OFFICES AND PLANT: CLIFTON BOULEVARD CLIFTON, NEW JERSEY

SALES OFFICES: CHICAGO CLEVELAND LOS ANGELES WASHINGTON

EXECUTIVE OFFICES

WORLD'S LARGEST MANUFACTURER OF GLASS BONDED

SUPRAMICA is a registered trademark of MYCALEX CORPORATION OF AMERICA for ceramoplastic material.

SYNTHAMICA is a trademark for the mica flakes manufactured by SYNTHAMICA CORPORATION, a subsidiary of MYCALEX CORPORATION OF AMERICA

RANSBURG
Electro-Spray
DOES IT BETTER... FOR LESS

50% INCREASE IN PRODUCTION

50% SAVINGS IN LABOR and OVERHEAD

66% CUT IN PAINT COSTS, with improved, more uniform, and higher quality finish.

Look what Ransburg Electrostatic Spray painting is doing in this eastern job shop, the Del-Val Finishers Division of J. W. Rex Company, Lansdale, Pa.

As a job shop, Del-Val handles a variety of work each month, painting hundreds of thousands of pieces and parts of various sizes and shapes.

The versatility and flexibility of Ransburg Electro-Spray makes it ideal for their varied painting requirements. Here's a typical example. Del-Val recently completed a contract for a Philadelphia manufacturer of barbecue trays with these results:

The job—flat sheet steel, 11" x 19"—enamel coated to withstand a 90 bend with sharp radius. Full coat one side; mist coat other.

WITH RANSBURG ELECTRO-SPRAY		BY FORMER HAND SPRAY	
Output, 375 panels per hour with 3 men		Output, 250 panels per hour with 4 men	
	per panel		per panel
Labor and overhead	.06	Labor and overhead	.12
Paint & lease cost	.017	Paint cost	.044
TOTAL COST	.077	TOTAL COST	.164

Want to know what Ransburg Electro-Spray can do for you in YOUR finishing department? Write for our new No. 2 Process brochure. It tells the WHAT & HOW of electrostatic spray painting, and with numerous production-line examples, shows how other manufacturers are cutting finishing costs... increasing production, and improving the quality of their work with Ransburg equipment. Too, we have available now a new movie, "The Big Attraction," a 27-minute sound and color film on electrostatic spray painting.

Ransburg ELECTRO-COATING CORP.
Indianapolis 7, Indiana

RANSBURG

For more information, turn to Reader Service Card, Circle No. 367

thicknesses from 1/32 to ½ in. Standard finish is a semigloss and standard color is natural (light brown). It is supplied as a standard laminate or with copper foil on one or both sides for printed circuits. The material has high bond strength and good dip solder resistance.

Electrodes, Solders, Fluxes for Joining

Recent developments in joining materials include a paste type brazing flux for high alloy steels, rare metal solders and a new type of iron powder welding electrode.

1. Build-up electrode

An electrode for building up carbon steel parts preliminary to hard-facing has been marketed by *All-State Welding Alloys Co.*, 249-55 Ferris Ave., White Plains, N.Y. Alloyed to resist plastic deformation upset and over-roll under severe working conditions, the low cost electrode eliminates spalling of expensive overlay alloys.

Called Roll Matrix, it is inherently wear resistant but it is not classed as a hard-surfacing rod. A.c. or d.c. deposits from the electrode exhibit 30 Rockwell C hardness and cannot be machined or forged unless preheated to 400 F or red heat.

The electrode is used as the first step in retreading carbon steel parts that have become excessively worn, e.g., tractor track rollers, sprockets, idlers, churn drill bits, mixer blades, bearing journals, steel mill rod ends and wobblers. Steels containing 0.35 to 0.90% carbon, including those alloyed with chromium, nickel, molybdenum, etc., can be rebuilt. Recommended practice is to rebuild where not more than ¼ in. thickness of hardfacing material is required. Roll Matrix is made in core diameters of ⅛, 5/32, 3/16 and ¼ in. *(continued on p 170)*

Remarkable PLASTISOL ...improves so many products it's an industry itself!

So versatile is plastisol (Exon 654 in the Firestone line of vinyl resins) that its uses are spreading rapidly throughout industry.

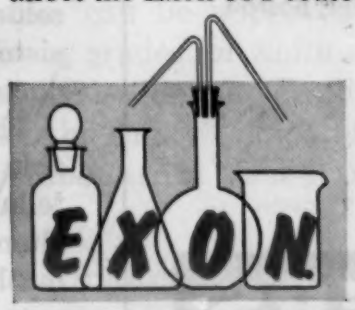
All kinds of products are being made better to sell better, with the benefits of plastisol compounds made with Exon 654.

Look at the picture above—plastisol at work! *Slush molded* of Exon 654, the doll acquires a natural look and feel, a washable skin. The supermarket wagon is *dipcoated* with Exon 654 so moisture can't rust it. Exon 654 plastisol *coating* makes the handbag fabric more durable, colorful, fashionable. Greases can't affect the Exon 654-coated dish drainer.

Even the car itself! It can actually cost less because plastisol reduced production costs! Assembly lines now use grappling hooks to lift the chassis because abrasion-proof plastisol coatings on the hooks prevent marring or scratching the car surface. And the car's battery and other parts were made in a plant that coated its tanks with Exon 654 so that acids wouldn't corrode them.

This remarkable plastisol, Exon 654, is just one of the many resins in industry's most complete line of versatile vinyls. It is another reason why industry looks to Firestone Exon for engineered answers to its needs.

because it's made of **Firestone**



VERSATILE VINYL RESINS
engineered answers to industry's needs

Firestone Plastics Company supplies the plastisol resin only...does not make compounds or finished products.

For complete information or technical service on the entire line of Exon resins, call or write today:
CHEMICAL SALES DIVISION
FIRESTONE PLASTICS CO., DEPT. 63-M, POTTSTOWN, PA. • A DIVISION OF THE FIRESTONE TIRE & RUBBER CO.

• For more information, turn to Reader Service Card, Circle No. 447

No doubt about it — Felt by Felters is "teased" into just the right fiber arrangement for extra resiliency and long wear.

It does not crumble under pressure or deteriorate under continuous operation. Has predictable permanent set, is not adversely affected by age, water, oil, gasoline or acid in normal concentrations. It can be used with glass, wood, metal or plastics and treated chemically to meet technical and industrial requirements.

FELT IN USE . . . Felt is widely used as filtering medium, from the respirator use shown here to filtering out impurities in oil and similar fluids. Felters Felt comes in variety of densities, has high absorption and is an effective, low-cost seal against dust and dirt.

Free Design Book

Find out about *all* the ways felt can help you in product design. Complete data in handy form, even to selection and ordering of right grades. It's yours for the asking. Send for it today: The Felters Company, 220 South Street, Boston 11, Mass.

Get the Best, Specify

FELT by FELTERS

Manufacturers of Felt and Felt Products — *Represented in All Principal Cities*

FES-2a

For more information, turn to Reader Service Card, Circle No. 543

OTHER NEW MATERIALS PRODUCTS

Paste flux is applied to a stainless part before brazing.

2. Paste brazing flux

A new paste type brazing flux permits high temperature brazing of stainless and other high alloy steels. Called Nicrobraz Flux, it is made by *Stainless Processing Div., Wall Colmonoy Corp.*, 19345 John R St., Detroit 3, Mich.

The flux is claimed to provide better joints on stainless steel, permit high temperature brazing with an oxyacetylene torch without special atmospheres, permit use of less expensive atmospheres in furnace brazing, and allow the brazing of titanium- or aluminum-bearing stainless alloys in hydrogen atmospheres.

The flux has a melting point below 1200 F and is recommended for brazing applications between 1600 and 2200 F. Its cleaning properties enable it to dissolve or remove chromium, aluminum and titanium oxides from stainless steels.

3. Rare metal solders

Solder microforms containing rare metal elements ranging in purity from 99.9 to 99.999+ are made by *Anchor Metal Co., Inc.*, 244 Boerum St., Brooklyn 6, N. Y. They are designed to meet the need for near absolute purity in solders used to join parts of transistors, diodes and other semiconductors.

The solder microforms are available in indium, gallium, selenium, tellurium, gold, platinum, silver, aluminum, arsenic, antimony, bismuth, cadmium, copper, tin, zinc and lead. They can also be obtained in a wide selection of "doped" alloys such as indium-

Anaconda specifies Enjay Butyl rubber

TO DEFY OZONE IN HIGH-VOLTAGE CABLES...

for more current per circuit...more power per dollar

Anaconda specifies Enjay Butyl insulation for high-voltage cables because this rubber has incredible resistance to ozone. Surpassing the industry's standard three-hour specification test, Enjay Butyl insulation used by Anaconda showed *no injury after 72 hours* of ozone concentration tests—24 times longer than specification requirements. Other rubbers would deteriorate and crack in a fraction of this time.

With the help of Enjay Butyl, millions of feet of Anaconda's cable now in use deliver more current per circuit, more power per dollar.

Perhaps *your* product, too, can be improved with versatile Enjay Butyl. It comes in non-staining grades for white and light-colored parts, offers excellent electrical properties, low price and *immediate availability*. For full information, contact the Enjay Company. Complete laboratory facilities and technical assistance are at your service.

ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.
Other offices: Akron • Boston • Chicago • Los Angeles • Tulsa

• For more information, turn to Reader Service Card, Circle No. 463

How About Malleable?

Strong on cost saving features . . . and strong on physical properties

Malleable iron castings simplify design and production, improve appearance of finished product.

Malleable foundries are helping manufacturers of innumerable products to solve parts problems with this versatile material. Examples multiply daily — a wide range of shapes, sizes and weights. Standard and pearlitic malleable castings offer broad opportunities for simplifying design, reducing weight, increasing strength and *lowering production costs.* Here are two recent interesting examples:

Shifter fork, formerly 3 pieces, produced in one pearlitic malleable iron casting at a cost reduction of 44½%.

Hoist housing, once built up of 6 pieces, now made in standard malleable iron. Cost — 31.7% lower.

Malleable iron, in use for over 130 years, has many remarkable properties. It will pay you to consult your nearest malleable foundry, or write to this Society for information.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building — Cleveland 14, Ohio

For more information, turn to Reader Service Card, Circle No. 573

gallium, indium-gold, indium-tin, gold-gallium, gold-antimony or tin-arsenic. Almost any desired combination can be made to satisfy design requirements.

4. All-position electrode

An all-position electrode for a.c. or d.c. operation produces little spatter even with amperages higher than normal for this type electrode. Made by *Hobart Bros. Co.*, Hobart Square, Troy, Ohio, it is called Hobart 212 and is recommended for use where fit up is poor. The weld deposit is uniform, smooth and convex in shape.

5. Iron powder electrode

An iron powder electrode has been designed to meet the proposed AWS classification E6014. Known as Airco Easyarc 14, it is available from *Air Reduction Sales Co., Div. of Air Reduction Co., Inc.*, 60 E. 42nd St., New York 17. It has no tendency to flat-top and its smooth beads and easy slag removal make it applicable for horizontal fillets.

Easyarc 14 operates well on low open circuit voltage, especially with a.c. transformers of the farm welder type. It is used in vertical down welding of sheet metal and ornamental iron and all types of mild steel fabrication.

6. Spooled wire

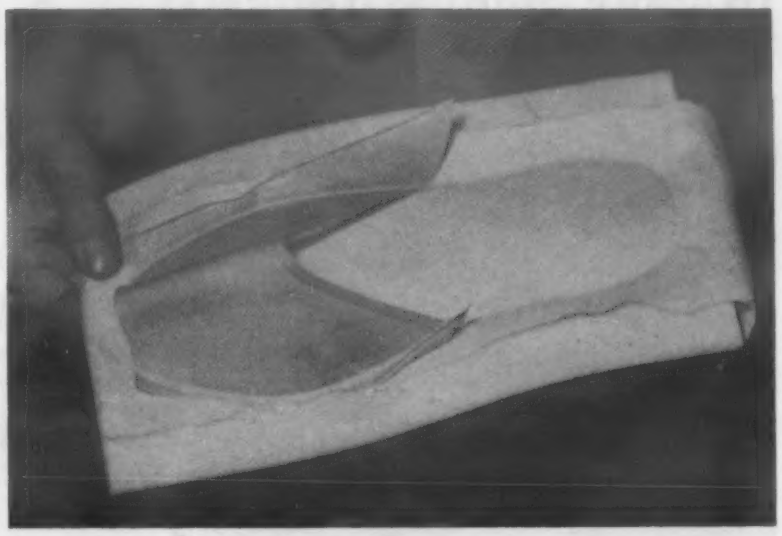
A nickel-aluminum bronze electrode in spooled form has been developed for welding nickel-aluminum bronze cast ship propellers and turbine runners. Used with the inert-gas consumable electrode process, it is made by *Ampco Metal, Inc.*, 1745 South 38th St., Milwaukee 46, Wis.

Called Ampco-Trode 46, it produces a deposit of high ultimate tensile strength, yield strength and ductility. The material is said to resist corrosion, erosion and cavitation-pitting better than manganese bronzes previously used for turbine runners and large ship propellers.

7. Low hydrogen electrode

Low hydrogen, iron powder electrodes claimed to have less

One-step manufacturing with heat-sealed vinyl foam

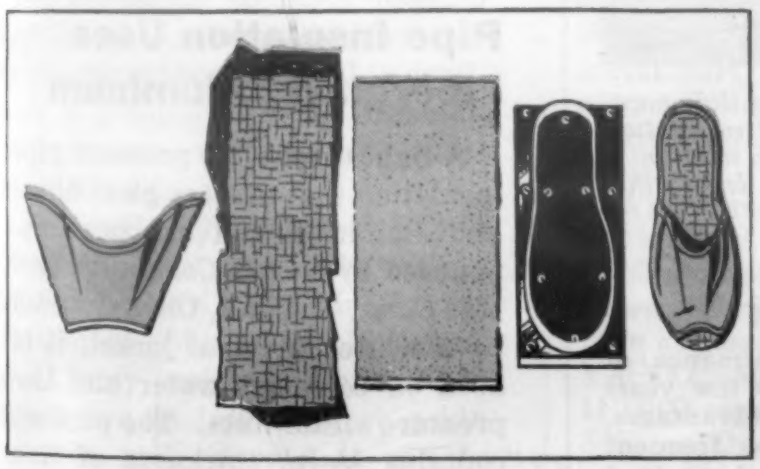


■ *For a wide range of products, you can combine virtually all manufacturing operations into a single processing step by using vinyl foam and new heat-sealing methods.*

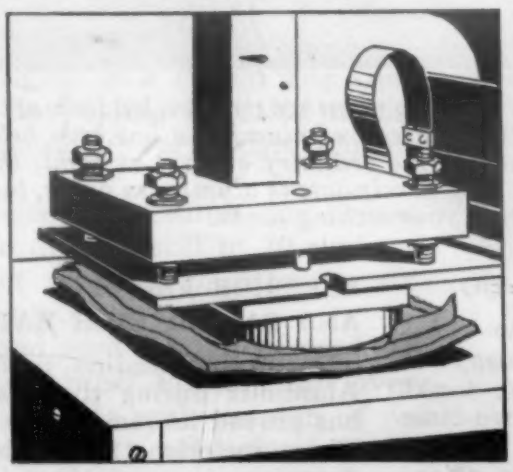
Vinyl foam heat-seals to itself, to vinyl film, to coated fabrics, Saran, and many other synthetic or natural fabrics. The heat-sealing—in one operation—can form, mold, and permanently bond together several component parts. You can eliminate production steps such as shaping, sewing, and gluing . . . and you can use a "tear-seal" die to eliminate preliminary cutting and the final trim finishing. Vinyl foam can give you:

- *Built-in cushioning*
- *Wear and abrasion resistance*
- *Unlimited choice of colors*
- *Resistance to soaps, oils, acids, alkalis*
- *Fire resistance*

Three-piece lounging slipper is fabricated in one processing operation



Start with vinyl film top, vinyl foam insole, embossed vinyl film outersole.



Shape, mold, and permanently bond component parts in a "tear-seal" die with a single heat-sealing operation.

The "tear-seal" die allows the slipper to be removed by simple hand-tearing.

MONSANTO

Where Creative Chemistry Works Wonders for You

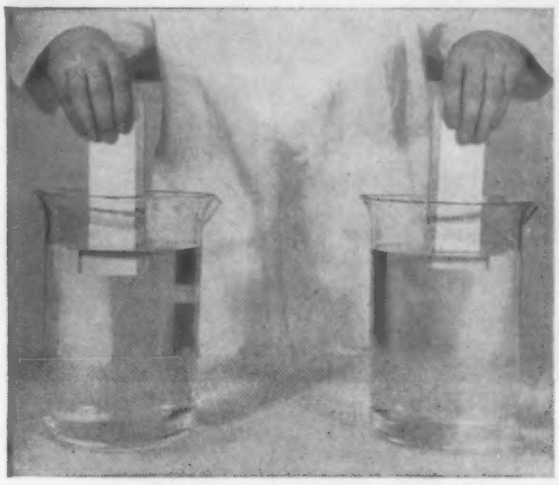
You can also fabricate vinyl foam by die-cutting, splitting, skiving, molding, stitching, hot-wire shaping or forming. Monsanto manufactures plasticizers and vinyl resins for vinyl foam . . . but does not produce or distribute the finished formulations. For sources of vinyl foam sheets or slabs, write MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, Department ID-4 St. Louis 1, Mo.

For more information, turn to Reader Service Card, Circle No. 535

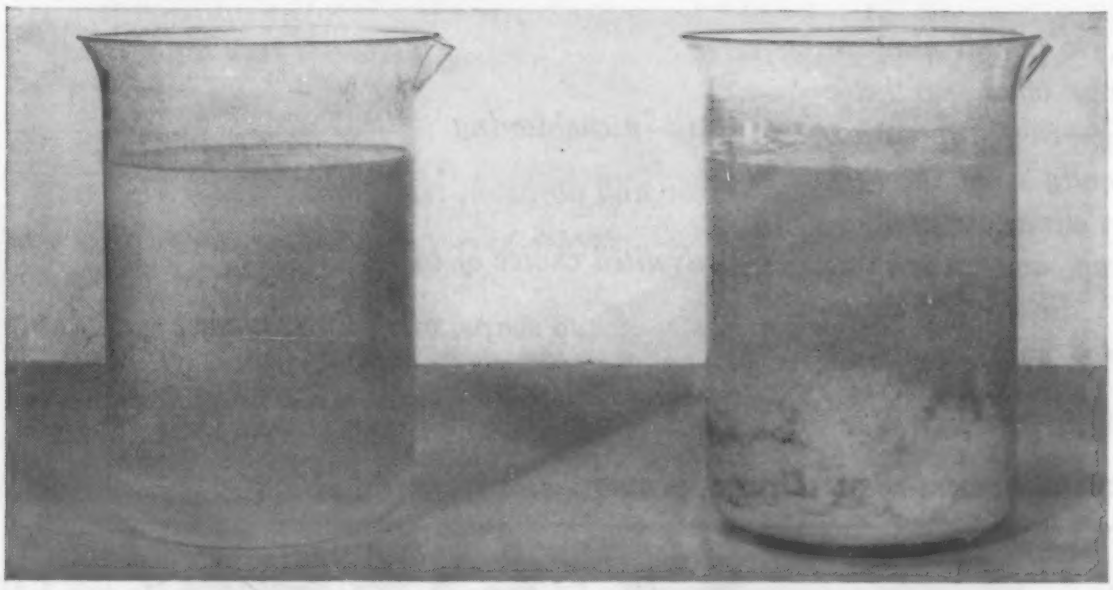
How Aluminux etching process prevents

ROCK-HARD SCALE

in your etching tanks



IDENTICAL ALUMINUM EXTRUSIONS *are placed in equal-strength solutions of Diversey Aluminux (left) and an ordinary etchant (right).*



ALUMINUM HAS NOW BEEN DISSOLVED IN BOTH SOLUTIONS, *but look at the difference! In the Aluminux solution at left, the dissolved aluminum has been held in solution with no trace of precipitate. But, in the ordinary etchant at right, the solution is cloudy with a heavy precipitate. This precipitate is aluminum oxide, the deposit that builds up as rock-hard scale inside your etching tanks.*

WHAT SCALE IS COSTING YOU

Any way you look at it, the time-consuming job of hacking away at scale inside aluminum etching tanks is a terrible waste. It means down-time and lost production, wear and tear on equipment, non-productive use of expensive labor (and probably at overtime rates). Scale runs up costs in other ways too, such as cutting down efficiency of heating coils and adhering to work in process.

The serious problem of scale and sludge in etching tanks has been successfully eliminated by the Diversey Aluminux process. As these photos show, Aluminux contains a chemical agent that holds dissolved aluminum in solution, instead of depositing it on tank walls and heating coils in the form of sludge and scale. In a 1500 gallon tank, for instance, Aluminux holds up to 1,000 lbs. of dissolved aluminum in solution . . . *a potential one ton of scale that would otherwise have to be chipped off!*

SUPERIOR FINISH AND FASTER ETCH RATE

The production-line performance of Aluminux during the past few years has proved its remarkable advantages. These include: (1) Far less frequent dumping . . . solutions last up to 4 times longer with no scale build-up, (2) superior, even, diffused satin-finish and cleaner work, (3) faster rate of etch and increased production, (4) lower maintenance costs . . . tanks are simply hosed out when re-charging, (5) precision control of degree of etch.

For more facts about the exceptional savings other manufacturers are getting with Aluminux, ask your nearby Diversey D-Man. You'll find him an experienced, dependable consultant on your metal finishing problems.

For an interesting illustrated brochure on the Aluminux process, write today to Metal Industries Department, The Diversey Corporation, 1820 Roscoe Street, Chicago 13, Illinois.

For more information, turn to Reader Service Card, Circle No. 490

OTHER NEW MATERIALS PRODUCTS

susceptibility to moisture pick-up have been developed. Designated Murex Speedex HTS, these electrodes of the E7016 type are made by *Metal & Thermit Corp.*, 100 E. 42nd St., New York 17. Said to deposit more pounds of weld metal per hour than conventional electrodes, they are used for all-position welding of hard-to-weld steels. The deposits are easily controlled and the slag is light and friable.

8. Rosin core solder

An activated rosin flux that removes tough surface oxides from most metals is available in the new metal solder made by *Anchor Metal Co., Inc.*, 244 Boerum St., Brooklyn 6. Noncorrosive and nonconductive, the rosin core flux meets Federal Specification QQS-571B. The solder is claimed to be suitable for copper, brass, nickel plate, cadmium plate, German silver and other metals that previously required a corrosive acid flux.

Pipe Insulation Uses Fiberglass, Aluminum

A lightweight low pressure pipe insulation that utilizes glass fibers and aluminum foil has been announced by *Owens-Corning Fiberglas Corp.*, Toledo 1, Ohio. Covered by a white universal jacket, it is used on cold, hot water and low pressure steam lines. The product contains ½-in. thickness of fine fibered Fiberglas insulation and a jacket of heavy, bleached creped Kraft paper laminated to aluminum foil.

The aluminum foil provides an efficient vapor barrier and the glass fibers are inorganic and dimensionally stable. The insulation will not rot or shrink. Its conductivity value averages 0.24 Btu per hr per sq ft per in. at 75 F. The product is designed for use at 50 to 250 F.

(more New Materials on p 177)

Nickel Undercoating for Rhodium Plate

A nickel plating process has been developed by *Sel-Rex Precious Metals, Inc.*, 229 Main St., Belleville 9, N. J. Used with Sel-Rex Bright Rhodium, it is said to produce a hard ductile, compressively stressed nickel undercoating for rhodium.

Known as Lectro-Nic, the coating counteracts rhodium electroplate's inherent tendency to crack and peel. It is said to eliminate the peeling and curling common in printed circuits and other precision components that have been plated with ordinary tensile-stressed metals. It is also claimed to offer greater wear resistance and a more tenacious bond than is possible by conventional means.

Liquid Neoprene Paint Has Good Shelf Life

Du Pont's neoprene provides high resistance to many organic and inorganic chemicals. Now this synthetic rubber material is available in a liquid form for brushing or spraying without the usual shelf-life limitations.

Designated Rubber-Coat Liquid Neoprene, it is supplied by *Wilbur & Williams Co.*, 130 Lincoln St., Boston 35, Mass., in black, red, light gray and aluminum. As a protective coating against acids, caustics and solvents, it can be applied on structural sheet shapes, pipes and irregular areas. Among other applications, it can be used for nonslip handles on tools or to patch and repair canvas belting and rubber hose.

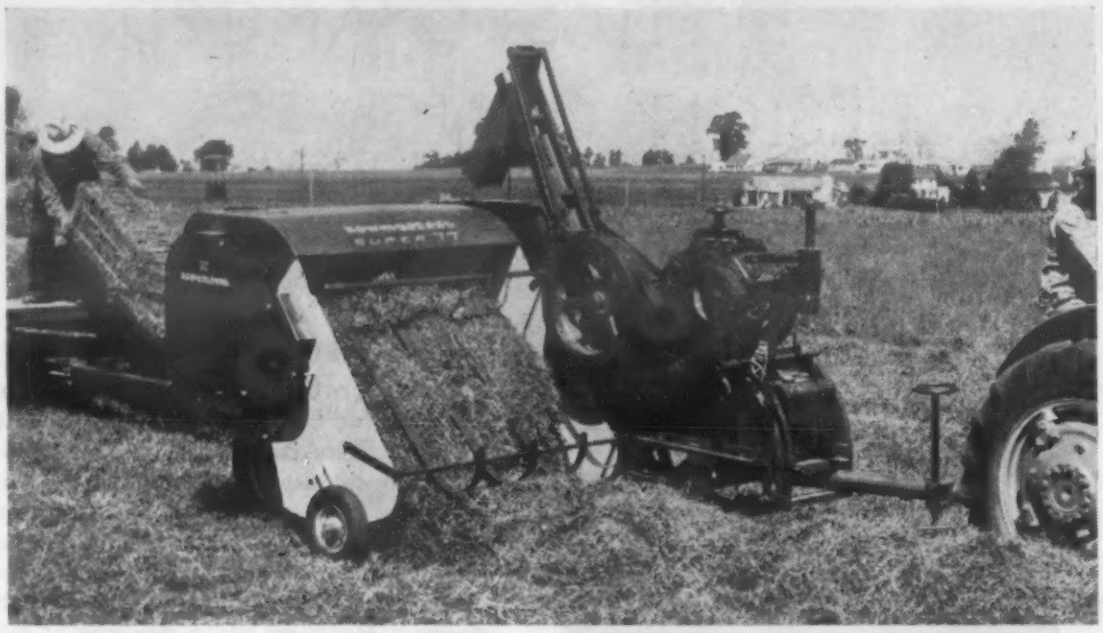
Glass Fiber Mats

Glass fiber reinforcements are now made by *Famco, Inc.*, Louisville 8, Ky., a subsidiary of American Air Filter Co., Inc. The reinforcing mat, surfacing, and

For more information, Circle No. 361

INCREASED PERFORMANCE

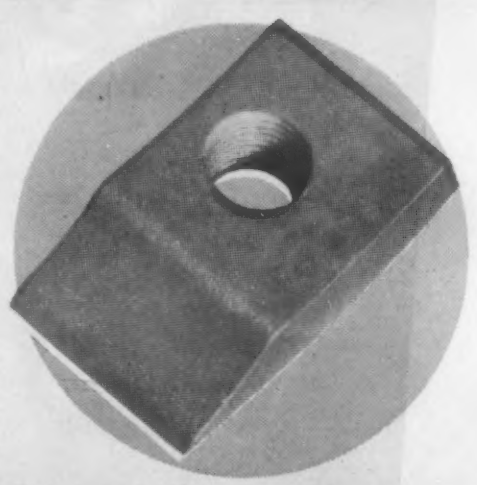
plus 34% COST REDUCTION on vital hay baler part!



Thanks to VASCO

Pre-Alloyed STEEL POWDER

On this exacting agricultural machinery application*, the strength and toughness of VASCO Pre-Alloyed Steel Powders show to typical advantage. The powdered metal part (right) is a clutch dog that actuates the hay baling knotting mechanism, withstanding very high impact loads.



When engaged, the clutch dog drives the knotter from standstill to 70 rpm—a sudden impact repeated as often as six times per minute.

In accelerated wear tests, dogs made of VASCO 4630-A Steel Powder ran over 110,000 engagements with no sign of wear! Add to this a cost saving of 34% on the manufactured item, and you have still another example of a tough parts problem solved by VASCO high-strength steel powders.

Vasco Pre-Alloyed Steel Powders

Precise metallurgical control insures that each particle of *pre-alloyed* VASCO steel powder has the same analysis as the entire melt. This alloying by melting means that high tensile strength and other special properties can easily be developed by simple heat treatment. Standard pre-alloyed powders available from stock are AISI 304 and 316 Stainless, and 4630-A Alloy Steel. Other compositions are available for special requirements. Write.

*Name of manufacturer on request

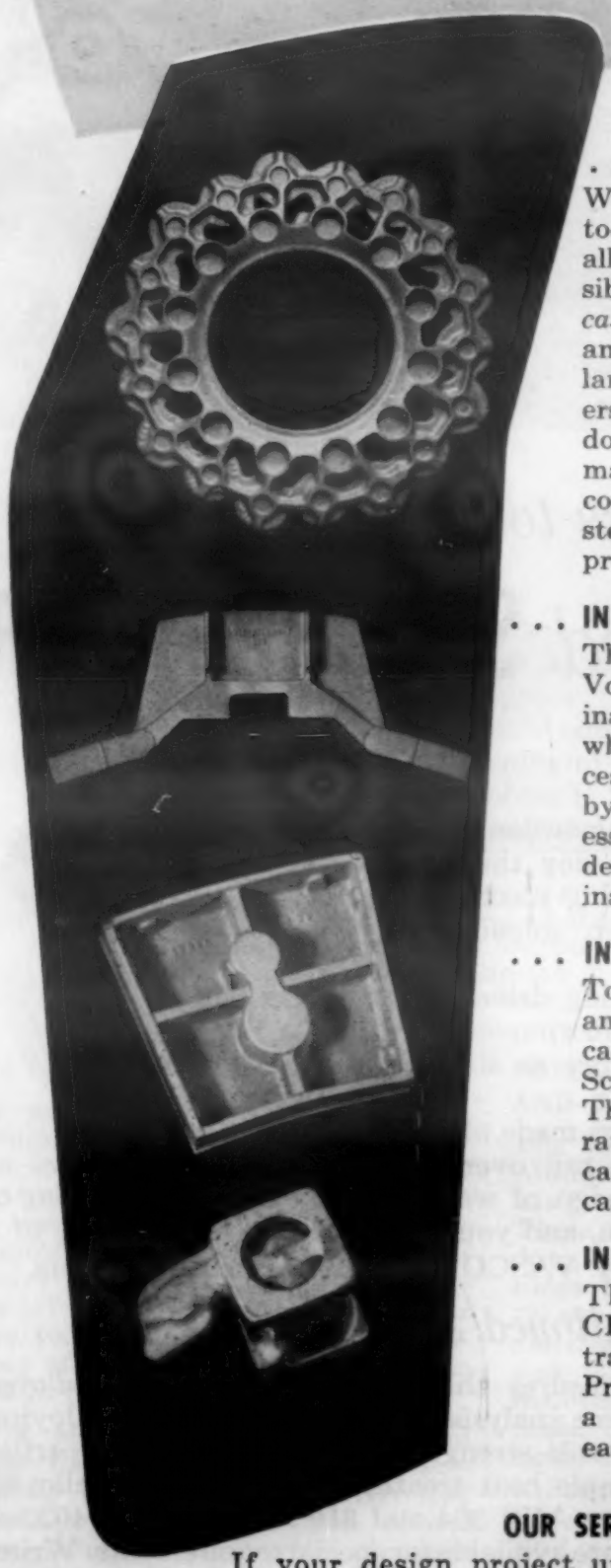
Vanadium-Alloys Steel Company

Latrobe, Pennsylvania

SUBSIDIARIES: Colonial Steel Co. • Anchor Drawn Steel Co. • Pittsburgh Tool Steel Wire Co.
Vanadium-Alloys Steel Canada Limited • Vanadium-Alloys Steel Societa Italiana Per Azioni

For more information, turn to Reader Service Card, Circle No. 473

CERAMICAST* HAS CHANGED DESIGN CONCEPTS . . .



. . . IN AIRCRAFT BRAKE SYSTEMS

When aircraft landing speeds became too fast for braking systems of light alloys, CERAMICAST made it possible to produce backing plates in *cast steel* that will stand the stresses and high temperatures placed on the landing gear of today's super bombers and fighters when they "touch down." Backing plate designs of six major U.S. aircraft have now been converted from light alloys to the cast steel of Lebanon's CERAMICAST process.

. . . IN JET ENGINE COMPONENTS

This jet removal track for the Chance Vought F8U-1 *Crusader* was originally designed as a machined part, which made quantity production excessively expensive. Now produced by Lebanon's CERAMICAST process in cast steel, the part retains the desirable characteristics of the original, at a considerable cost saving.

. . . IN THE BOTTLING INDUSTRY

To produce the surface smoothness and close tolerances of this bottling cap guide, engineers at Pneumatic Scale Co. specified CERAMICAST. The thin metal sections and accurately recessed pockets are significant advantages of Lebanon's new casting process.

. . . IN AIRCRAFT FUEL SYSTEMS

The unique advantages of the CERAMICAST process are illustrated in this jet engine fuel valve. Practically impossible to produce as a sand casting, this component is easily adaptable to CERAMICAST.

OUR SERVICE TO YOU

If your design project utilizes cast steel in any form, CERAMICAST may provide quality and cost advantages. Let our engineers discuss the process with you and its applicability to your problems. Write for complete descriptions and applications of the CERAMICAST process.

* CERAMICAST is a registered trademark

CIRCLE L

LEBANON STEEL FOUNDRY

113 LEHMAN STREET LEBANON, PENNSYLVANIA

CARBON, LOW ALLOY AND STAINLESS STEEL CASTINGS

For more information, turn to Reader Service Card, Circle No. 500

decorating mat are made of continuous glass fibers mechanically interwoven and bonded with various resins. The decorative mat is supplied with a starch binder and is made with striking designs woven into the mat itself. The surfacing mat is white and is claimed to be uniform, wrinkle-free and easy to work.

New O-Ring Compound

A synthetic rubber compound, designated 47-731, that meets requirements of AMS-7271 is available from *Rubber Products Div., Parker Appliance Co.*, 17325 Euclid Ave., Cleveland 12, Ohio. O-rings molded of this fuel resistant compound are suitable for −65 F service.

Heat Resistant Leather

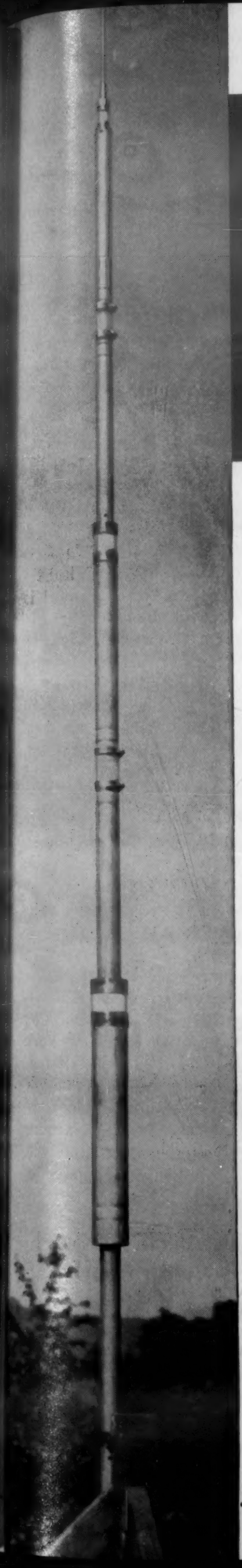
A new process has resulted in a heat resistant leather. Called Insuleather, it does not become brittle and resists shrinking when subjected to intense heat. According to the manufacturer, *Jaxco, Inc.*, Sturtevant, Wis., tests have proved that Insuleather will remain pliable when subjected to 1000 F for 30 sec. Shrinkage under these conditions is held to about 10%. The leather retains no heat and can be handled immediately.

Carbon Base Compound for High Temperatures

An inert material suitable for operating temperatures up to 3000 F has been developed for use in brazing fixtures and heat treating jigs. Called Sur-Braze Grade M300, it is made by *Technion Design & Mfg. Co.*, 262-72 Mott St., New York 12.

This new grade of Sur-Braze, a carbon base compound, will withstand extremely high tempera-

For more information, Circle No. 570 ▶



Mast of
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provides high strength and corrosion resistance for coaxial antenna

The Type 3006 Coaxial Colinear Antenna*, consisting of three half-wave vertical dipoles arranged colinearly and operating on a frequency range of 152-176 MC, is especially suitable for patrol car broadcasting. The three vertically arranged dipoles exhibit a gain of 5 to 6 db over a standard single dipole, and produce a low angle of radiation with equal radiation in all directions.

This 13½-foot, 40-pound antenna is supported by a mast made of Shelby Seamless Tubing (USS Stainless Steel) running through its center. In addition to possessing the tensile strength to withstand 100-mile-per-hour winds, this stainless supporting mast has high corrosion resistance—will not flake from oxidation and cause short circuits.

In such critical applications where superior strength, uniformity, dimensional accuracy and corrosion resistance are needed, Shelby Seamless Tubing of USS Stainless Steel is consistently chosen to meet the requirements. Shelby Seamless Tubing, available in a wide range of diameters, wall thicknesses, various shapes and steel analyses, is produced to exacting standards by the world's largest manufacturer of tubular steel products. If you wish, our engineers will make a study of your requirements, and will help you apply Shelby Seamless Steel Tubing to your specifications.

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are being used in the power plants, gyro- and servo-mechanisms, and on various other types of equipment. Production orders may run into thousands of pieces or as few as desired.

Parts that must resist the terrific temperatures encountered are being cast in the excellent heat-resistant alloys like Hastelloy, Stellite and Inconel. Ferrous and non-ferrous alloys are investment cast in shapes too costly to fabricate by other manufacturing methods.

As a result of using this process for producing a part, the fabrication process is simplified and sizable cost savings are made. In contrast with assemblies, greater uniformity and dependability are often obtained with investment castings.

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tures and thermal shocks and will not react with fluxes or brazing alloys. It can be milled, drilled, turned and threaded, and so lends itself to short runs or long-run work. It is available in rounds up to 3⅞ in. dia and 6 in. long, and in custom fabricated shapes.

Silver Plate Has Mirror Bright Finish

A bright silver plating process has been introduced by *Sel-Rex Precious Metals, Inc.*, 229 Main St., Belleville 9, N. J. Called the Silvrex process, it is claimed to give a mirror bright finish directly from the bath through a complete range from flash to extra heavy deposits.

The deposits are ductile and have a Brinell hardness of 135. The process operates at room temperature and is noncritical and economical. It can be used in a wide range of current densities from 10 to 40 amp per sq ft. Throwing power is good.

Lacquer for Butyrate

A lacquer for coating and decorating butyrate has been developed by *Schwartz Chemical Co., Inc.*, 326 W. 70th St., New York 23. Called Rez-N-Lac "B," it features permanent adhesion and low flammability. Nontoxic and completely waterproof, the lacquer cannot be scratched off and will not flake or craze. It is applied by brush or spray.

Coated Nylon Fabric in Greater Widths

Neoprene-coated nylon fabric is offered in widths of 138 and 144 in. by *C. R. Daniels, Inc.*, Daniels, Md. These widths allow the fabric to be used in a single, seamless piece in such applications as machinery

At this stage, #113 is just a number. If all proceeds as planned, it will shortly acquire a name — the name of Driver-Harris's newest special-purpose alloy . . . made, as always, to meet the needs of a specific manufacturer.

When someone asks us for an alloy we do not have, we try to make it. Usually we succeed. To date we have succeeded 112 times. Many of our long line of electrical, electronic, and heat-resistant alloys — Nichrome*, Nichrome* V, Advance*, Karma*, Manganin, Nilvar*, and the rest — are today famous names in industry the world over. And each of these was originally custom-made . . . produced exactly to the specifications of someone who needed it.

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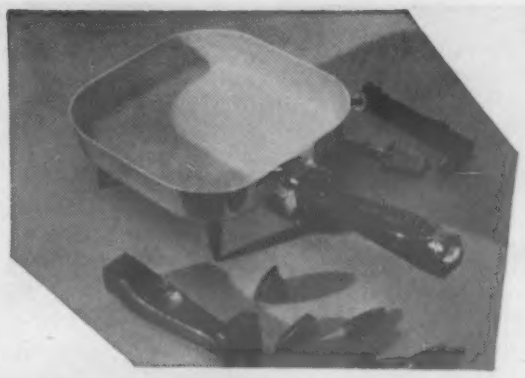

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OTHER NEW MATERIALS PRODUCTS

covers, tarpaulins, vat covers, partitioning curtains, windbreakers, portable repair sheds and cock pit and engine covers. This reduces fabrication cost and eliminates the possibility of leakage or seepage. The material is made in 16-oz weight, the lightest weight recommended by the company for outside use.

O-Ring Lubricant

A lubricant that extends the service life of synthetic rubber O-rings has been announced by *Rubber Products Div., Parker Appliance Co.*, 17325 Euclid Ave., Cleveland 12, Ohio.

The grease is applied to both the O-ring and the metal surfaces over which the O-ring must slide. The material is especially recommended for low pressure pneumatic and vacuum systems.

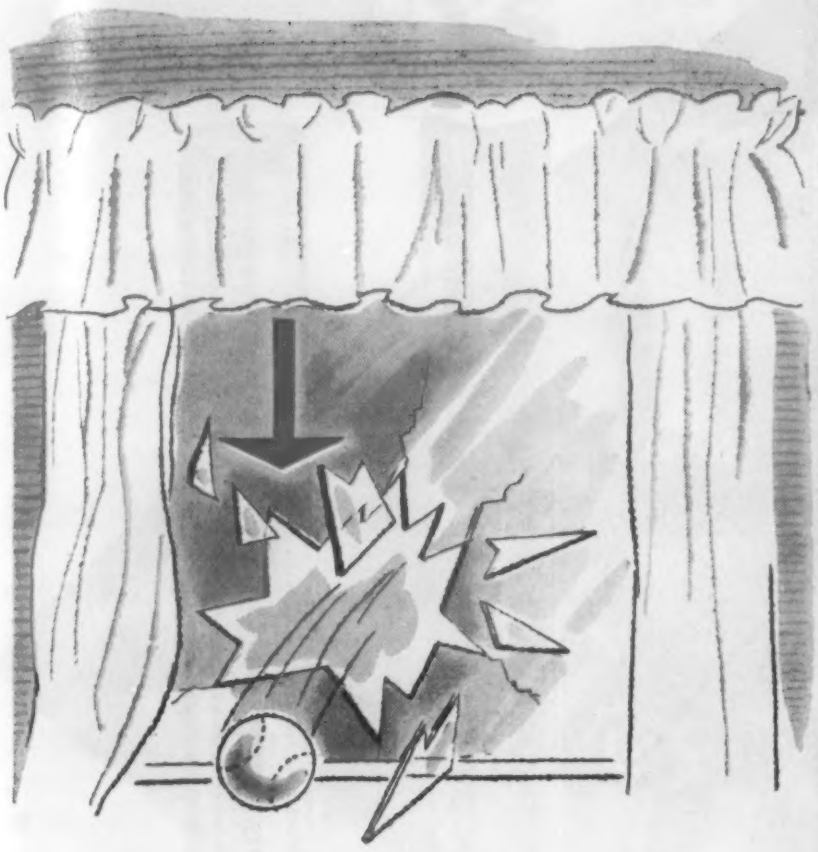
Hot Wire Insulation

A new thermocouple wire insulation is said to offer improved resistance to abrasion, solvent and acid resistance at temperatures up to 600 F. It is suitable for continuous operation up to 900 F in dry atmospheres. The insulation is made by *Revere Corp. of America*, Wallingford, Conn. Wire utilizing the insulation, built to meet specifications MIL-W-5845, 5846 and 5908, is available in various gage sizes to thermocouple and lead wire accuracy.

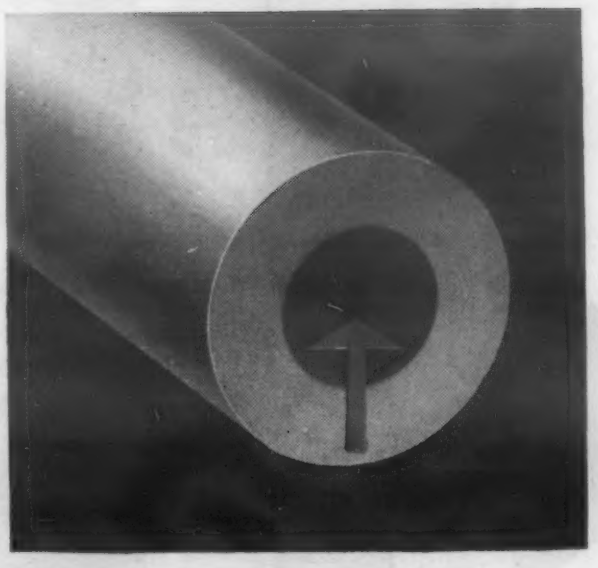
Gray Iron Castings

Coming in October

This 16-page Manual presents the basic, up-to-date data needed for intelligent selection and design of gray cast iron—one of the least expensive and most serviceable materials available to the engineer.



a hole here means work...



a hole here saves work

Crucible Hollow Tool Steel Bars take much of the work out of making ring-shaped steel parts, or tools with a center hole. The hole's already there. You save expensive drilling, boring, cutting-off and rough-facing operations . . . you reduce machine time and scrap losses.

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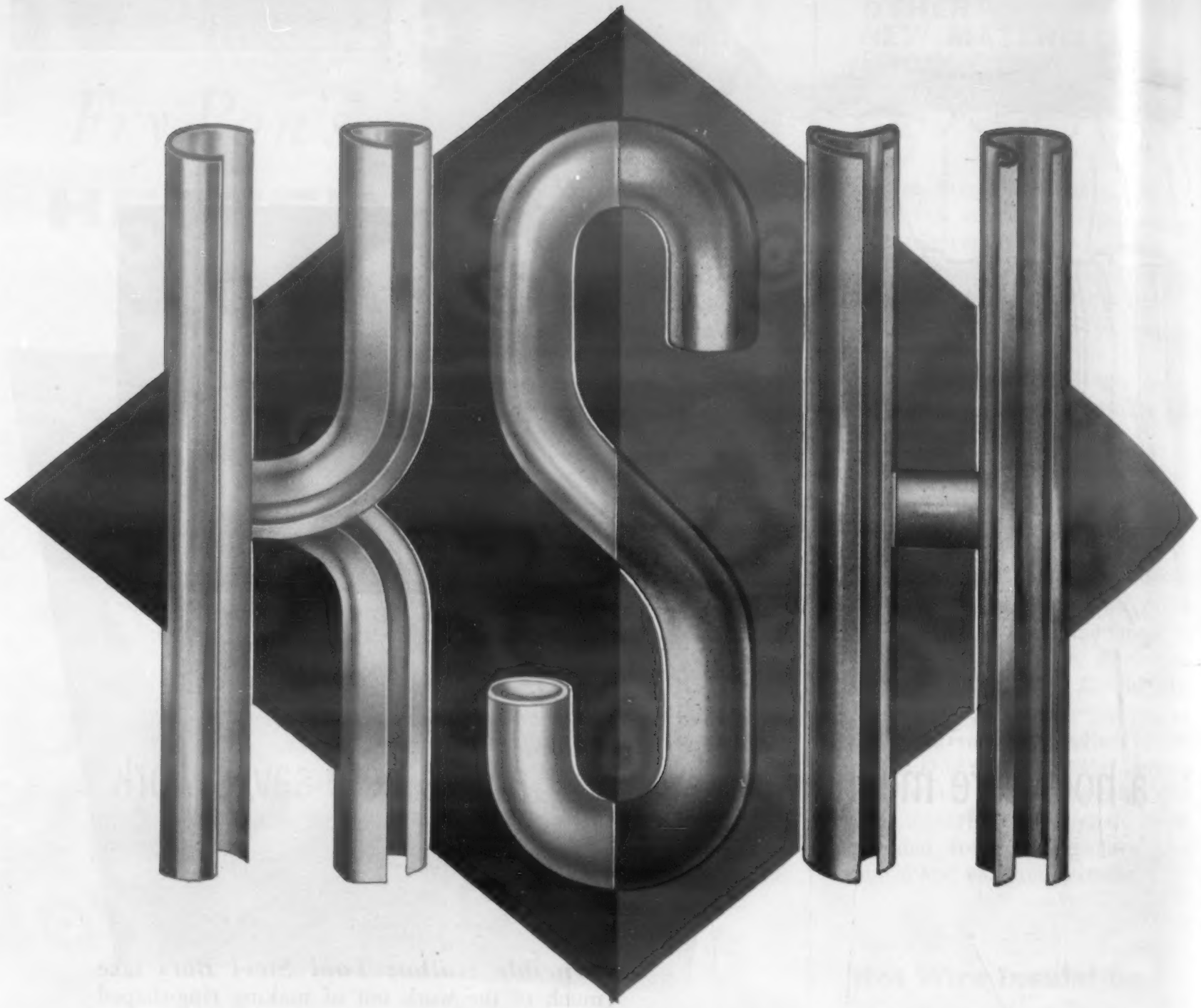

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CONTENTS NOTED

Highlights of current papers plus a list of recent books and reports.

This month

- *Cost of vacuum investment castings*
- *Phosphate coatings lower metal temperatures*
- *Fire resistance of electrical laminates*
- *Wax cuts polyethylene's permeability*

Economics of Vacuum Investment Castings

■ The investment process is the only major casting method that can be used without basic revisions for the production of vacuum castings of iron, nickel and cobalt alloys. At a recent meeting of the Investment Casting Institute, F. Kenneth Iverson of Cannon-Muskegon Corp. discussed the economics of vacuum investment casting and the reasons why producers of investment castings should consider installing the necessary equipment modifications.

Because vacuum melted high temperature alloys have proved superior to air melted alloys, the major consumers of high temperature investment castings are replacing present cast materials with vacuum melted wrought alloys. Based on preliminary tests and the fact that cast alloys generally outperform the wrought version of the same alloy in high temperature service, however, there is good reason to believe that vacuum investment cast alloys can have equal or better properties than vacuum melted wrought alloys.

Whether or not investment casting in vacuum is economically practical becomes a major consideration. What must be the selling price of the castings? The accompanying table, presented by Mr. Iverson, gives a good indication of the premium that users of vacuum cast alloys can expect to pay.

HOW AIR, ARGON AND VACUUM INVESTMENT CASTINGS COMPARE IN COST

Item	High Alloy Material			Low Alloy Material		
	Air	Argon	Vacuum Remelt	Air	Argon	Vacuum Remelt
Mold Cost[a]	$35.00	$35.00	$35.00	$28.00	$28.00	$28.00
Metal Cost per Mold[b]	16.00	40.00	40.00	3.20	27.20	27.20
Melting Cost per Mold	2.60	5.20	9.70	2.60	5.20	9.70
Cleaning, Cutoff, Inspection	18.00	18.00	18.00	8.00	8.00	8.00
Total Cost	71.60	98.20	102.70	41.80	68.40	72.90
Minus Metal Returns	6.24	6.24	6.24	.55	.55	.55
Net Cost	65.36	91.96	96.46	41.25	67.85	72.35
Plus Margin[c]	19.61	27.59	28.94	8.25	13.57	14.47
Selling Price per Mold	84.97	119.55	125.40	49.50	81.42	86.82
Selling Price of Casting[d]	15.17	21.35	22.39	7.28	11.97	12.77
Increase in Price over Air Melting	—	40.3%	47.7%	—	64.4%	75.3%

[a]Based on ½-lb casting, 8 castings per mold.
[b]Based on 50% yield not including rejects and a vacuum metal cost that is $3.00 per lb over comparable air melted alloys.
[c]30% for high alloy materials and 20% for low alloy materials.
Allowing 30% rejects for high alloy castings and 15% rejects for low alloy castings.
Note: All figures include depreciation and overhead. Initial cost of vacuum furnace capable of pouring 10 flasks per hr: $60,000.

Phosphate Coatings Protect Flame-Exposed Parts

Tests recently completed by the National Advisory Committee for Aeronautics indicate that the temperature of certain metal parts exposed to hydrocarbon flames can be reduced through the application of a phosphate coating. According to a technical report prepared by G. C. Fryburg, N. H. Katz and S. L. Simon of the NACA Lewis Flight Propulsion Laboratory in Cleveland, the lower operating temperatures are believed to result from the high emittance of the phosphate coating. The coating may be used on the outside surface of engine combustor cans or on other airplane components where maximum heat loss by radiation is desired.

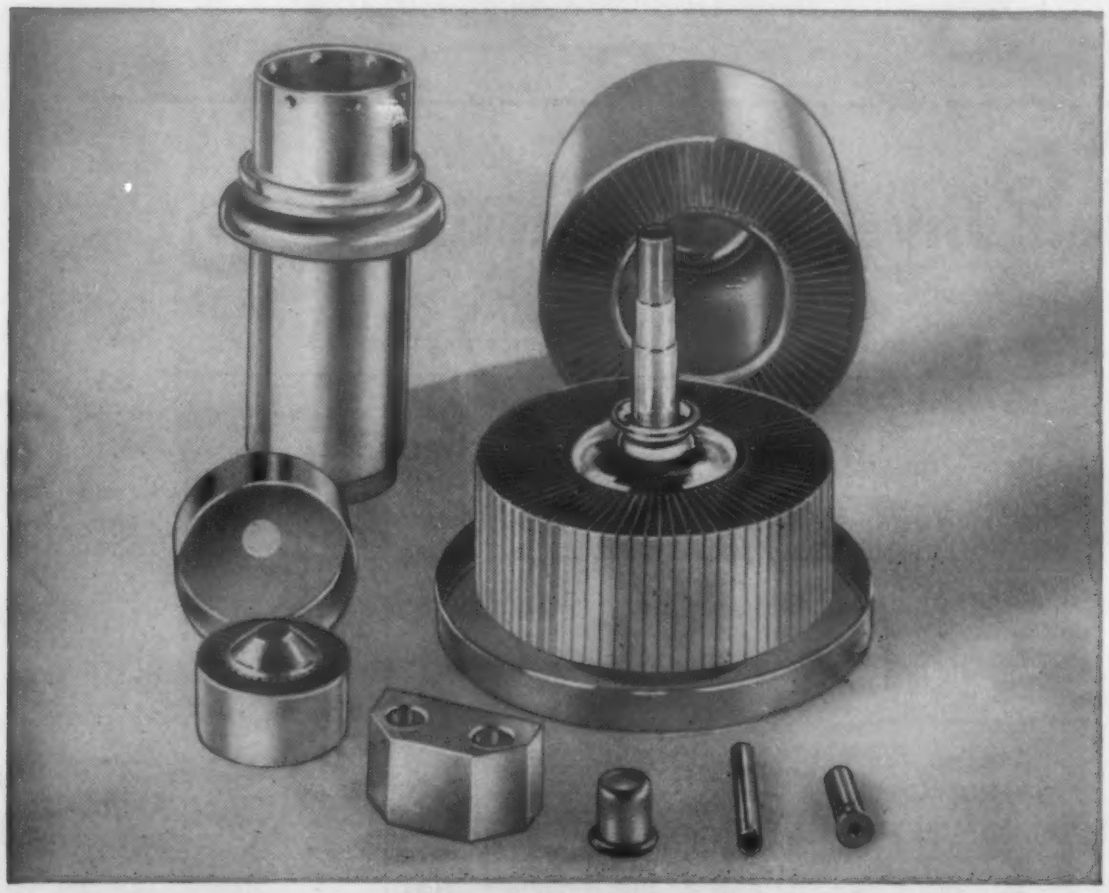
Tests were conducted with SAE

BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

Bridgeport Brass Co.

Reporting new developments in copper-base alloys and metalworking methods.



Bridgeport Alloys Used for Heart of Transmitting Tubes

Today's rapid developments in radar and communications give increasing importance to the electron tube for generating and amplifying ultra-high and microwave frequencies for radar and communication systems.

In manufacturing electron tubes, Eitel-McCullough, Inc. of San Bruno, California—a leading producer of transmitting tubes—faced several difficult problems. The primary problem was that vacuum tube production requires firing at extremely high temperatures in a hydrogen atmosphere. Under these conditions, ordinary copper becomes spongy and porous. Specifying Bridgeport Oxygen-Free copper provides the solution.

Other major requirements for metals also exist. While the majority of electron tube components are formed, many are machined to exact dimensions from rod and tube. Eitel-McCullough requires a metal that can be easily fabricated in deep-drawing, is a good electrical conductor and is adaptable to plating. Here, too, Bridgeport alloys proved to be the solution.

Bridgeport alloys are used because they can meet Eitel-McCullough's exacting requirements in manufacturing and finished product performance, as well as providing consistently uniform composition. Bridgeport O.F.H.C. copper is used for many tube parts—anodes, support structures, coolers, cooler cores, drift tube sections, index sleeves and static sleeves.

Transmitting tubes are one of many products using Bridgeport Alloys for special applications. Your product, too, can use Bridgeport "job matched" alloy. Call your nearest Bridgeport sales office today.

The Importance of "Machineability"

Low-cost, large-volume production depends on the "machineability" of the metal used to do the job. In establishing the machineability ratings of alloys, Bridgeport Metallurgists consider these five factors the most important: speed of machining... tool life... finish... accuracy... and power required.

While copper and each of its alloys have individual characteristics, Bridgeport copper-base alloys have been grouped into three broad machineability classifications:

Free-Cutting Alloys

Machineability rating 100% to 70%. All alloys in this group are leaded, and produce short, brittle chips. For example, most jobs that call for free-cutting brass rod can be entrusted to Bridgeport Ledrite #6 Standard, machineability rating of 100%. Ledrite #6 is easy to cut, gives longer tool life... products are smooth, clean-surfaced.

Moderately Machineable Alloys

Machineability rating 70% to 30%. This group covers some leaded refractory alloys and some non-leaded brasses. Bridgeport Duronze III, a silicon aluminum bronze, is also included in this classification.

Difficult to Machine

This group includes non-leaded copper, phosphor bronze, silicon bronze, nickel silver and commercial bronze. All produce long, tough, stringy chips.

Finding the right metal or alloy, with the right machineability rating is no chore—if you call Bridgeport. Close cooperation with our Technical Service Division has worked wonders for many fabricators—increasing quality and uniformity, reducing waste, cost of labor and materials. Write or call your nearest Bridgeport Sales Office for high-quality alloys, and for free expert advice in your metal selections. (1155)

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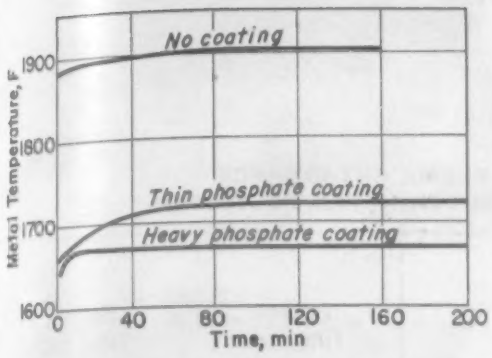

Fig 1—*Temperatures of uncoated and phosphate-coated specimens of SAE 1020 mild steel in flame environment.*

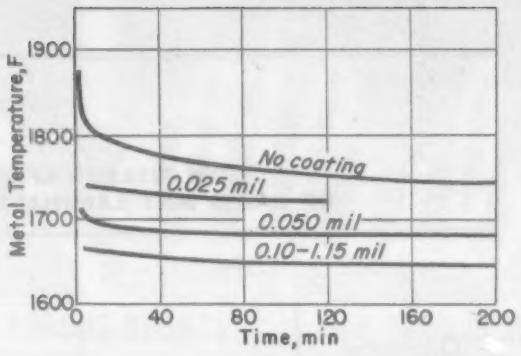

Fig 2—*Temperature of uncoated and phosphate-coated specimens of S-816 alloy.*

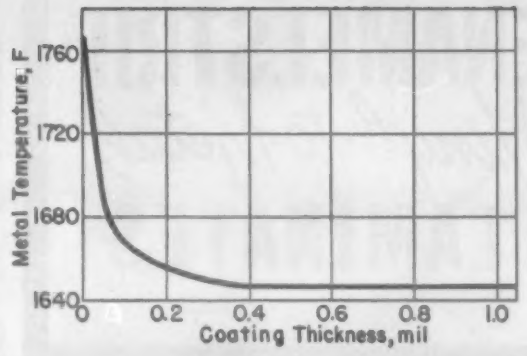

Fig 3—*How thickness of the phosphate coating affects temperature of S-816 alloy.*

1020 mild steel and S-816 alloy (20 Cr, 20 Ni, 44 Co, 4 Mo, 4 W, 4 Nb, 3 Fe and 0.4 C). The mild steel was coated with a manganese phosphate solution. Coatings consisted of mixed secondary and tertiary phosphates of iron and manganese. Because coating of the S-816 alloy could not be achieved with the solutions used for mild steel, a special anodizing method was developed. Specimens were cleaned in an alkali cleaner, then anodized in a very dilute solution of orthophosphoric acid (adjusted to a pH of 2.0) at a current density of 150 milliamp per sq in. and with a large cylinder of AISI 347 stainless steel as the cathode.

As shown in Fig 1, uncoated specimens of mild steel attained a temperature of 1900 F. Because of the lack of oxidation of the steel by the flame gases, this temperature remained constant throughout the tests. Identical specimens provided with a phosphate coating attained a temperature 200 F lower, or about 1700 F.

Uncoated specimens of S-816 alloy (Fig 2) reached a temperature of 1900 F, but this temperature dropped to 1750 F as a result of oxidation of the specimen. Phosphated specimens attained a temperature about 100 F lower. This temperature was maintained even after 300 hr of flame exposure. The effectiveness of various thicknesses of the phosphate coating in lowering specimen temperature is shown in Fig 3.

Fillers Retard Burning of Electrical Laminates

Several methods can be used to improve the generally poor fire resistance of electrical grade polyester laminates. Special fire resistant type laminates are usually either expensive or have physical or electrical properties inferior to those of general purpose laminates and so are used only where flame resistance is essential. Incorporating chlorine in the polyester molecule produces good flame resistance, but cost is increased and arc resistance lowered. Use of chlorinated hydrocarbons as fillers retards burning but lowers arc resistance and decreases elevated temperature stability.

Mineral fillers not only retard burning but also lower costs and generally improve mechanical properties of laminates. Fillers, of course, only retard burning to the extent that they act as diluents of the combustible components. Results of such use of inert fillers

HOW FILLERS AFFECT ARC RESISTANCE AND DIELECTRIC STRENGTH

Polyester Resin		Glass Mat, %	Filler		Arc Resistance (ASTM), sec	Dielectric Strength, v/mil[a]
Type	%		Type	%		
Chlorinated	66.7	33.3	—	0	8	350
Gen. Purpose	60.0	40.0	—	0	70	496
Chlorinated	33.3	33.3	B	33.3	75	350
Gen. Purpose	38.3	33.3	B	28.4	125	350
Chlorinated	41.9	33.3	A	24.8	134	436
Chlorinated	35.3	33.3	A	31.4	161	433
Gen. Purpose	38.3	33.3	A	28.4	173	173

[a]Perpendicular to laminations, step by step.

HOW FILLERS AFFECT FLAME RETARDANCE OF GLASS MAT LAMINATES (GENERAL PURPOSE POLYESTER)

Composition, %			Burning Rate[a], in./min
Resin	Glass Mat	Filler	
60.0	40.0	0	1.20
38.3	33.3	28.4 B[b]	0.674
38.3	38.3	28.4 A[b]	0.186

[a]ASTM-D-635-44. [b]Type of filler. See text.

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HOW FILLERS AFFECT FLAME RETARDANCE OF GLASS MAT LAMINATES (CHLORINATED POLYESTER)[a]

Composition, %			Ignition Time, sec[b]	Burning Time, sec[b]
Chlorinated Resin	Styrene	Filler		
66.7	0	0	129	176
33.3	0	33.3 B[c]	121	128
28.4	9.55	28.4 B[c]	115	254
30.8	10.3	24.8 A[c]	176	69

[a]All laminates contain 33.3% glass by weight.
[b]Tested by Fed Spec LP 406B Method 2023.1.
[c]Type of filler. See text.

were described by J. K. Allen of Westinghouse in the June issue of *SPE Journal.*

Tests were carried out on glass mat-based laminates made in a small production mold using two fillers. Filler B was a mineral compound, predominantly calcium carbonate. Filler A was a finely divided inorganic compound of comparable specific gravity and slightly higher in price than Filler B. Both general purpose and chlorinated polyesters were used, with styrene acting both as the crosslinking agent and as a diluent to reduce viscosity and permit large amounts of fillers.

The accompanying tables show the results of ASTM and Federal tests on burning rate, ignition time, arc resistance and dielectric strength of both general purpose and chlorinated samples. Laminates made with Filler A show several improvements over those containing Filler B. A laminate made with general purpose resin and containing 38.3 styrene, 33.3 glass mat and 28.4% Filler A required two 30-sec ignitions (ASTM D635-44) to start burning. After ignition, it burned 5 to 10 min with a weak but persistent flame and had an average burning rate of 0.186 in. per min. A similar laminate with Filler B was consumed in one ignition after about 6 min, the burning rate being 0.674 in. per min.

When Filler A was used in chlorinated polyester laminates, outstanding flame resistance was obtained. A laminate containing 24.7% Filler A ignited in 176 sec and burned only 69 sec as compared to a 115-sec ignition time and 254-sec burn time for a comparable laminate containing 28.4% Filler B. Filler A appeared to produce the greatest improvement in flame resistance with chlorinated resins when a minimum of styrene was used.

Corrosion of Cr-Ni-Mn Steels

Corrosion properties of chromium-nickel-manganese austenitic steels in the range of 15 to 21 chromium, 2 to 6.5 nickel and 5 to 17% manganese were discussed by W. G. Renshaw and R. A. Lula of Allegheny Ludlum Steel Corp. at the annual ASTM meeting.

The influence of nickel is important in these steels but varies with chromium content. In boiling nitric acid, improvement resulting from increasing the nickel content is more pronounced at 17% chromium than at the 20% chromium level. Nitric acid corrosion rates comparable with those of 18-8 can be obtained with a 20 chromium -6 nickel -8% manganese steel. This composition also shows good resistance to localized attack and to boiling 50% lactic acid.

Manganese can be varied from

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CONTENTS NOTED

4 to 14% with no significant effect on corrosion resistance. On the other hand, increasing the chromium content improves corrosion resistance.

Types 201 and 202 are equal to types 301 and 302 in many mild environments such as acetic, citric and phosphoric acids. For more severe conditions or for localized conditions, the 20 chromium -6 nickel -8% chromium composition is comparable with type 304.

The intergranular corrosion resistance of chromium-nickel-manganese steel is the same as that of chromium-nickel steels. Lowering the carbon content prevents intergranular corrosion resulting from short sensitizing time periods, a result similar to that achieved with type 304L. Carbon content seems to be less critical in the new grades than in the chromium-nickel steels; apparently the maximum carbon content corresponding to the 0.03% maximum in the chromium-nickel grades is between 0.05 and 0.06%.

Like the chromium-nickel steels, chromium-nickel-manganese steels are subject to stress corrosion cracking. Resistance to stress corrosion does not appear to be associated with the chromium, nickel or manganese content provided the structure is austenitic.

New Method Simplifies Etching of Germanium

An electrolytic method for etching germanium is discussed by M. V. Sullivan and J. H. Eigler, of Bell Telephone Laboratories, in the February issue of the *Journal of the Electrochemical Society*.

In processing semiconductor materials for transistor devices, the surface must be etched to remove both mechanical debris formed in cutting and shaping operations and chemical contamination introduced during processing. In the past this etching has been done with corrosive chemicals such as hydrofluoric acid, nitric

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acid, bromine or hydrogen peroxide. Because of the corrosive nature of these chemicals, solder joints, lead wires and other portions of the device have had to be protected by masking them with an inert material, an operation that must be done under a microscope by a skilled operator.

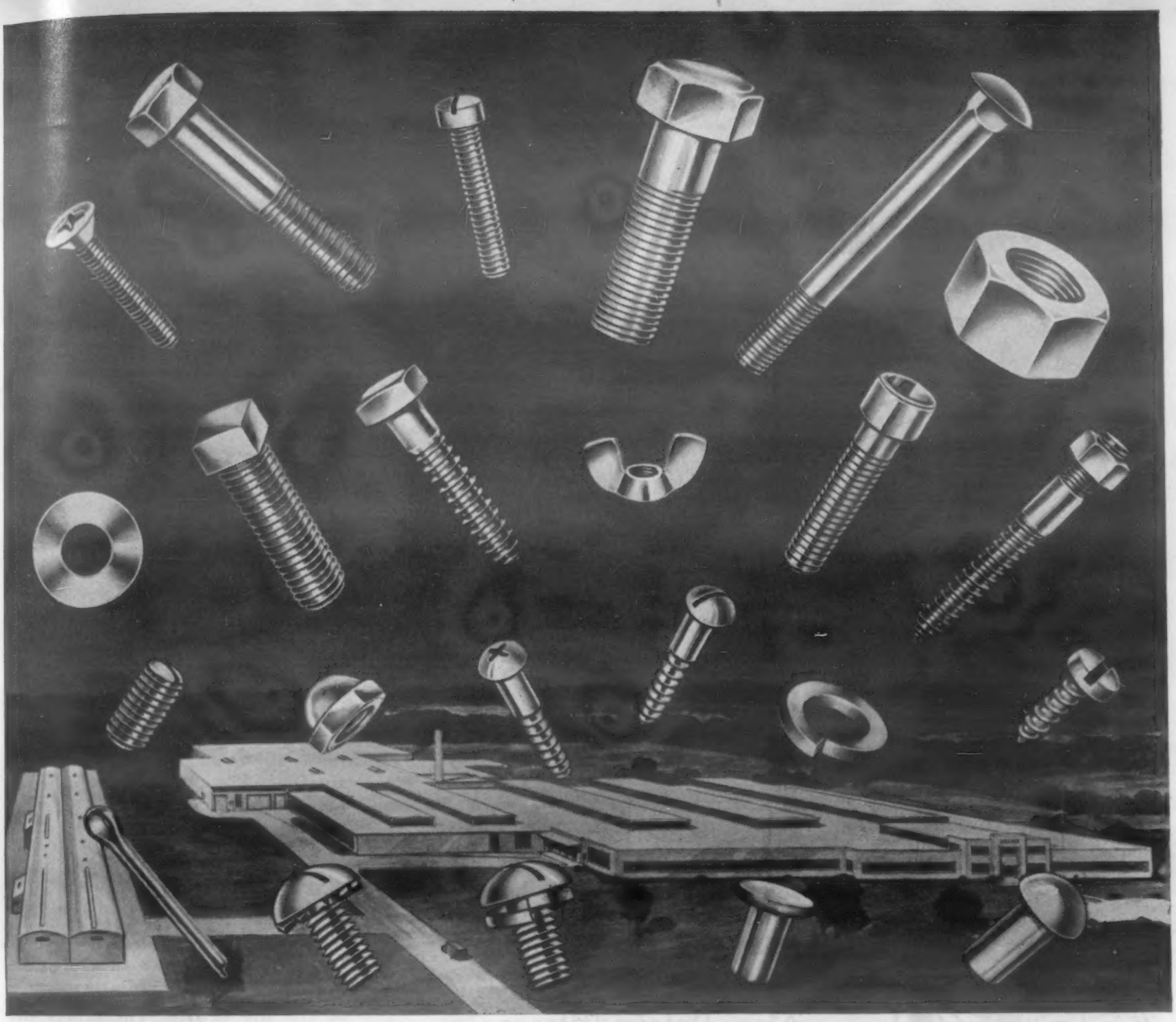
With the new electrolytic technique, the germanium is etched in a stream of 0.1% potassium hydroxide. By means of a special jig, etching is restricted to the junction area and masking is not required.

Metal Forming Operations Studied

Results of experimental and theoretical investigations of a number of metal forming and shaping operations are reported by W. Johnson, of the University of Sheffield (England), in the March issue of *The Journal of the Institute of Metals* (British). Operations studied include drawing and redrawing cylindrical shells, ironing, impact extrusion and coining.

The deep drawing process was investigated to obtain information sufficiently reliable to permit the prediction of 1) press load required for a particular operation, 2) stresses and strains induced in the sheet, and 3) degree of drawability of the material. Expressions derived theoretically were tested experimentally. Results showed that the mechanism of straining in the radial drawing region of a circular blank is thoroughly understood and strains can be predicted with confidence. Conditions over the punch head are not well understood and cannot be calculated readily. Lubrication has an important effect on the success of the operation. With both flat and round head punches, highest drawing ratios are obtained with lubricant applied to the die side only while lubrication of the punch side only is as bad as using no lubricant.

Investigations of redrawing



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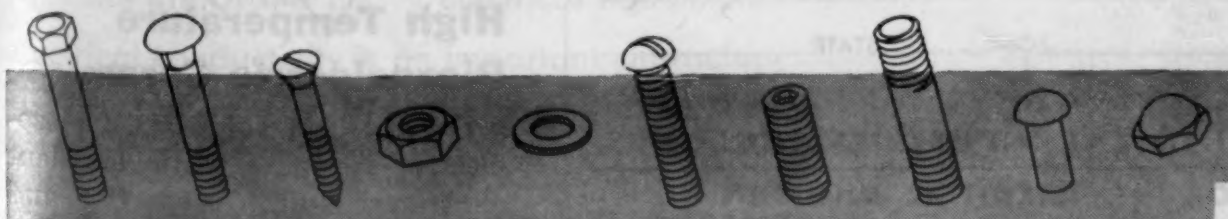

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showed that the maximum combined drawing capacity over two stages is obtained by using the largest first stage blank possible. Interstage annealing greatly improves redrawing capacity but tends to produce a redrawn cup of thicker walls and base and consequently smaller depth from a given blank.

Ironing, i.e., reducing the wall thickness of a cup by restricting the clearance between punch and die, has received little previous scientific study. This investigation showed that 1) press load is not directly proportional to the reduction in cup-wall area, 2) the degree of ironing reduction that can be safely effected is limited by the magnitude of the load transmitted through the punch head, and 3) optimum ironing conditions exist when the lubrication between die and cup is good and that between punch and cup is relatively poor.

In impact extrusion, tests show that about 90% of the work expended in achieving plastic deformation reappears as heat, generated in the immediate vicinity of the die orifice. Therefore, the more rapid the extrusion, the less time there is for the heat to diffuse from the deforming region to the undeformed regions. At slow extrusion speeds, there is a tendency toward "isothermal" extrusion, but at impact speeds the work rate is extremely high and extrusion is "adiabatic.

Investigation of coining showed that an excess of lubricant tends to reduce the precision of the coining operation, but that the optimum amount of lubricant reduces coining pressure appreciably.

High Temperature Piezoelectric Ceramics

Several lead oxide-based piezoelectric ceramics with excellent electromechanical properties and stability over a wide temperature range have been developed by the

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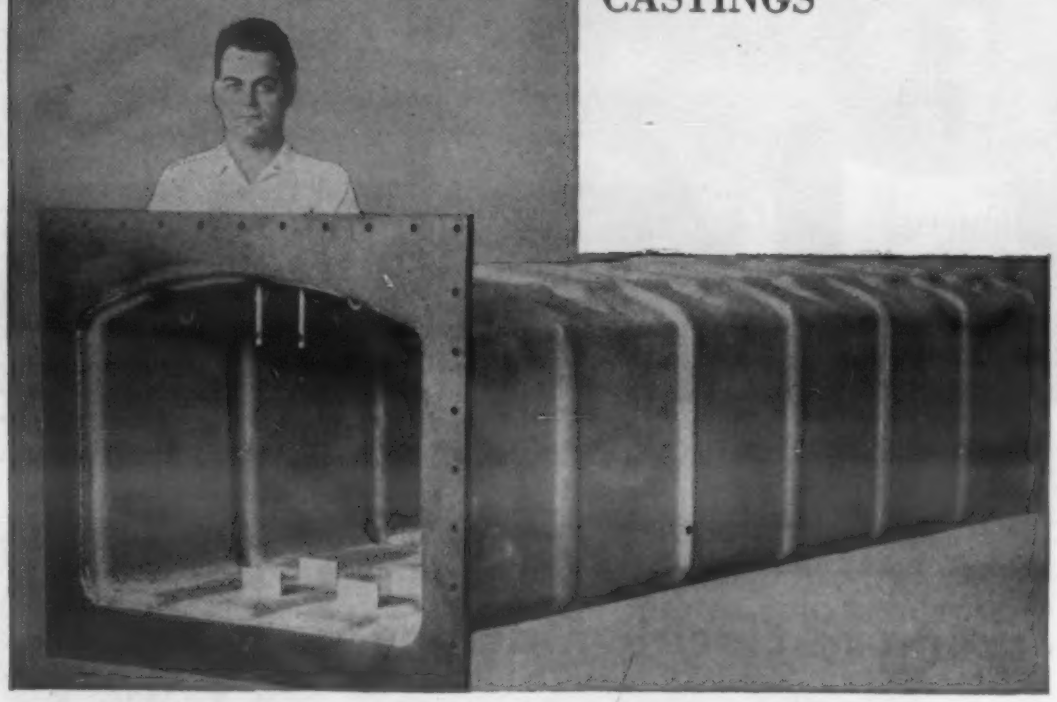

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LARGE or small DURALOY, can do it! These are just typical examples of the work moving through our foundry. Some of these castings are designed for heat resistance, some for corrosion resistance, some for abrasion resistance; all are cast by experienced foundrymen. All are carefully tested in our up-to-date laboratory.

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CONTENTS NOTED

National Bureau of Standards. They are expected to circumvent present limitations on barium titanate, which is effective only over a temperature range of 65 to 212 F.

The new materials should find use in transducers for sensing elements in accelerometers, sound detectors, sonar devices, velocimeters and strain and pressure gages, and as drivers in ultrasonic devices. Developed by B. Jaffe, R. S. Roth and S. Marzullo, of NBS, under sponsorship of the Army's Office of Ordnance Research, the ceramics are described in a *Summary Technical Report* published last September.

Piezoelectric ceramics are widely used as transducers for energy conversion between electrical signals and mechanical motion. The lead oxide-base ceramics were developed to produce a response that is uniform over a much wider temperature range than previously available materials.

One of the most useful compositions is 45 lead titanate, 55% lead zirconate. Its Curie point is approximately 645 F, compared with 250 F for barium titanate. The new ceramic has a radial coupling coefficient greater than 0.3 at 525 F, and a piezoelectric voltage output coefficient of 11.7 x 10^{-3} volt-meters per newton. This voltage coefficient is more than twice that of commercial barium titanate whereas piezoelectric charge output coefficients of both materials are comparable. Because of its high voltage coefficient, lead titanate-lead zirconate ceramic is particularly adaptable as a sensing element to convert mechanical motion or force into an electrical signal.

The addition of a mixture of lead and tin oxides to the lead titanate-lead zirconate ceramic provides another useful composition consisting of 47¼ lead titanate, 22¾ lead zirconate and 30% of the lead oxide-tin oxide mixture. This composition has the highest piezoelectric charge out-

your check list of . . .

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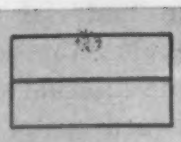
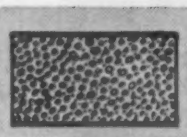
ADHESIVES

FOR PLASTICS AND METALS



RIGID

Acrylics; cellulosics; polystyrene and co-polymers; vinyl; nylon; vulcanized fibre; hard rubber; reinforced laminates of silicone, urea, melamine, polyester, phenolic, epoxy; flourinated resins; etc., and all metals.



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Polyurethane (polyester-isocyanate); polyvinyl chloride; polystyrene; epoxies; phenolics; etc.

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Which plastics? Which metals? Which rubbers? Which fibres? Porous or non-porous? How thick?

TYPE OF APPLICATION

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PHYSICAL PROPERTIES

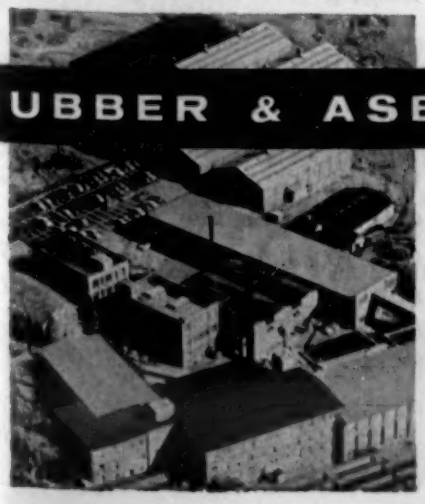
Maximum and minimum viscosity? Preferred drying time? Maximum drying temperature? Required tack time? Required pot life? Required vulcanizing conditions? Any pressure conditions?

SERVICE REQUIREMENTS

Bond strength (shear? peel? impact?) Film color? Flexibility? Toxicity? Stability? Odor? Government Specifications?

SERVICE CONDITIONS

Resistance to temperature? Which solvents? Which chemicals? Sunlight? Water? Cold? Heat (how much? how often?) Abrasion?



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CASE HISTORY 1

REQUIRED:

A dependable supply of this small, machined electrode to meet customer's quality and quantity needs at reduced cost.

HASSALL SOLUTION:

Hassall-designed re-heading process, involving no critical dimension changes, resulted in a 59% cost reduction to customer.

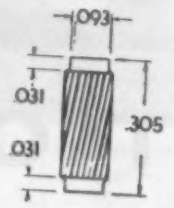
CASE HISTORY 36

REQUIRED:

Less costly manufacturing method for this small stainless steel fluted pin which cost $19.20 per M as a screw machine product.

HASSALL SOLUTION:

Cold forming by Hassall at a cost of $2.95 per M gave the customer an 85% cost reduction on this part.



CASE HISTORY 89

REQUIRED:

Customer looking for low cost, high production rate method of producing mandrels for rotary dental brushes.

HASSALL SOLUTION:

Hassall-originated design for cold-heading replaced chamfered end with tumbled, round end; maintained rigid specifications for straightness and made low-cost production possible.

CASE HISTORY 37

REQUIRED:

Bumper bolt with bonded rubber cap for license plate support.

HASSALL SOLUTION:

The large head on this bolt would ordinarily call for screw machining but the two lugs under the head ruled this out. Progressive cold-heading was Hassall's answer.

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put coefficient of all compositions examined, i.e., 74 x 10^{-12} coulomb per newton. This high charge coefficient makes the material useful as a driver or generator of mechanical motion.

Hot Workability of Steels Studied

To select the most economical and suitable equipment for hot working, it is necessary to know the amount of force that will be needed. This force consists of the resistance of the material to a change in shape plus the power needed to overcome internal shear and friction between metal and tool. Consequently, the first task in any investigation of plastic working is to determine the resistance to change in shape. Although it is relatively easy to obtain this true flow curve at room temperature, conditions are quite different at high temperatures such as those employed in forging.

In the Nov '55 issue of *Archiv für das Eisenhüttenwesen* (German), K. Fink, W. Lueg and G. Bürger report some results of using a new experimental method by which the true flow curve of steels at 1290 to 2190 F can be determined even by impact type upsetting under a drop hammer. The procedure (details of which are given in the article) makes possible a systematic investigation of the effect of composition on work hardening and recovery during hot working.

Four carbon steels and three low alloy steels commonly used in the German drop forging industry were selected for the study. Although there was still an appreciable difference among the various grades at 1290 F, they had almost the same resistance to change in shape at 2190 F. Even at 2190 F, work hardening during deformation could be observed.

Recovery during hot working was faster in the alpha than in

Formbrite cuts polishing cost 50% for Flexscreen®

Bennett-Ireland, Inc., drops cutting operation completely, speeds buffing—finds Formbrite also gives a more attractive, scratch-resistant finish.

This frame and the fender at bottom of page, both of Formbrite, are components of the Flexscreen ensemble shown above—one of many models manufactured by Bennett-Ireland, Inc.

Bennett-Ireland, Inc., Norwich, N.Y., previously used ordinary drawing brass for hearth fenders, kerbs, and frames in their famous flexible-metal fireplace screen ensembles. In polishing, the production rate was 12 frames per hour for the cutting operation and 4.5 frames per hour in the buffing operation.

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the gamma condition. With the carbon steels, the recovery rate increased with increasing carbon content, both above and below the austenite transformation temperature. The relatively small alloy content in the three alloy steels was insufficient to overcome the dominant effect of carbon content.

In hot working a carbon steel with about 0.5% carbon at 1470 F, resistance to change in shape decreased with increasing austenitic grain size regardless of whether the upsetting was longitudinal or transverse to the original rolling direction.

How Welds Influence Fracture of Structures

The influence of a weld on the fracture behavior of a structure is discussed by W. S. Pellini, of the Naval Research Laboratory, in the May issue of the *Welding Journal*. To obtain a proper evaluation of the influence of the weld it is necessary to compare the fracture characteristics of the weld metal with those of various base metals and also to determine the transition temperature of the welded joint.

The four possible paths along which fracture may propagate are: 1) base metal, 2) heat affected zone, 3) fusion line, and 4) weld metal. Propagation along any given path becomes possible only if the service temperature is below the critical fracture temperature for that zone.

Transition temperature of the weld metal can vary with the type of welding electrode. It is desirable to have a lower transition temperature in the weld than in the plate for, particularly if there is an appreciable difference, the weld can sometimes stop a brittle fracture.

A steel that fractures in a conventional ductile manner under a given set of conditions can fail in a brittle manner under other conditions, particularly if a sharp

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When both of these processes are used along with SRHS Chromium, benefits begin to multiply. The copper proves active for the nickel. In turn, the nickel shows unusual receptivity for the chromium. Passivity problems are eliminated. Downtime drops, rejects become rare.

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Bulletins supply details on each of the processes. Send for them.

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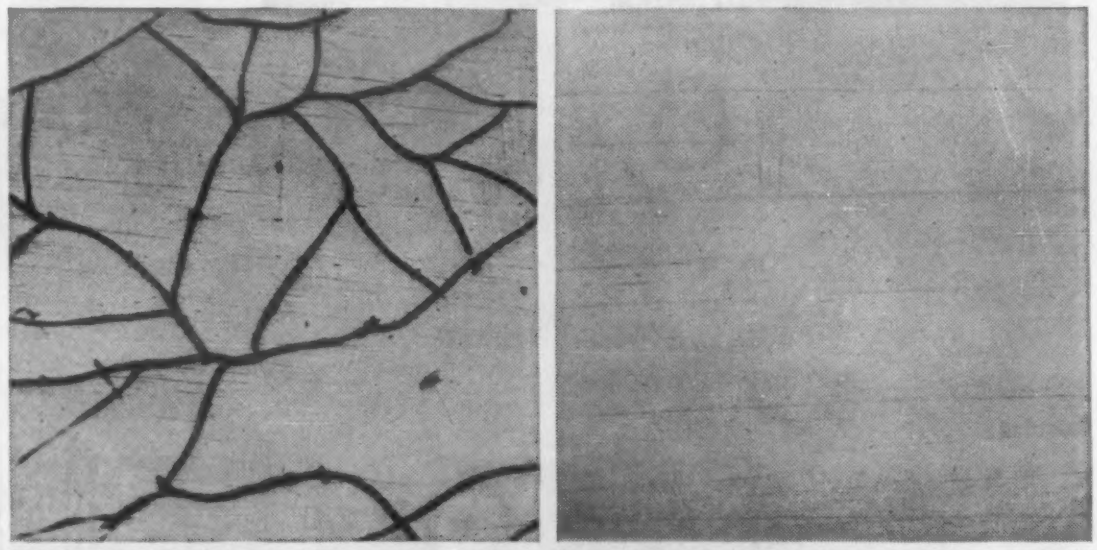

(Left) Surface view of etched ordinary chromium surface, enlarged about 75X, shows typical network of cracks. (Right) Etched Crack-Free Chromium surface shows none of this. Steel parts are therefore securely protected from rust.

Electrodeposits become continuous surfaces as thickness increases and porosity vanishes . . . except for *ordinary* chromium plate. Something else happens. Cracks develop as the chromium deposit builds up. Through these defects, corrosives reach the underlying metal. Unichrome Crack-Free Chromium eliminates these structural imperfections.

Comparative tests have demonstrated that Crack-Free Chromium makes a tremendous difference in corrosion protection.

At 110° F, and 100% relative humidity, only .0003" of Unichrome Crack-Free Chromium protected steel from rust for over 1000 hours. With ordinary chromium, identical parts were rust-covered in just *days*. In testing protection of .0005" of chromium plate in salt spray for 100 hours, one user found steel shafts protected with Crack-Free Chromium unaffected; while shafts with ordinary chromium were enveloped with rust.

WHERE TO USE

That is a question best answered by product designers. Knowledge of the complete advantages may suggest many uses. Crack-Free Chromium also offers:

1. Wear-resistance, hardness, and low friction.
2. Improved non-galling, non-seizing properties.
3. A more ductile deposit, resistance to thermal shock and better protection at elevated temperatures. Good impact resistance.
4. Excellent leveling action which helps cover surface imperfections. Also easier, faster grinding, if required.
5. Protecting the base metal without undercoats, Crack-Free Chromium can be used directly on steel or zinc base die castings for many applications.

APPEARANCE

A satin, matte finish, Crack-Free Chromium can be left as is, or readily buffed to high luster. Ask for recommendations, or send for Bulletin CFC-1.

For more information, turn to Reader Service Card, Circle No. 458

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notch is present. Stresses above yielding are required in the area of the point of origin to initiate brittle fracture, no matter how sharp the notch. This holds true for all temperatures below that defined as the *nil ductility transition temperature.*

Below a critical temperature, brittle fractures propagate if a certain minimal stress level is exceeded. With only moderate increases in temperature above this critical point, the stress required for crack propagation rises rapidly to values approaching the yield strength. The point at which this sharp rise occurs is designated the *fracture transition temperature for elastic loading.* Above this temperature plastic deformation is associated with fracture and a point is soon reached at which only ductile tearing occurs. This final transition is the *fracture transition temperature for plastic loading.*

These three transition points can be determined by several types of notch tests including the Charpy V-notch test, the crack-starter explosion test and the drop weight test.

Although transition temperatures determined by notch tests are valuable in design, the data are still qualitative. Notch tests have been correlated with service performance for only a few steels.

How SAP Compares with Other Light Metals

How SAP (sintered aluminum powder) compares with aluminum alloys and titanium at elevated temperatures is discussed by A. von Zeerleder in the Nov '55 issue of *Zeitschrift für Metallkunde* (German).

Mechanical properties of SAP are between those of pure aluminum and fully hardened aluminum-copper-nickel alloys. Precipitation-hardened aluminum-copper-nickel and aluminum-copper-magnesium alloys show a marked drop in strength at temperatures under

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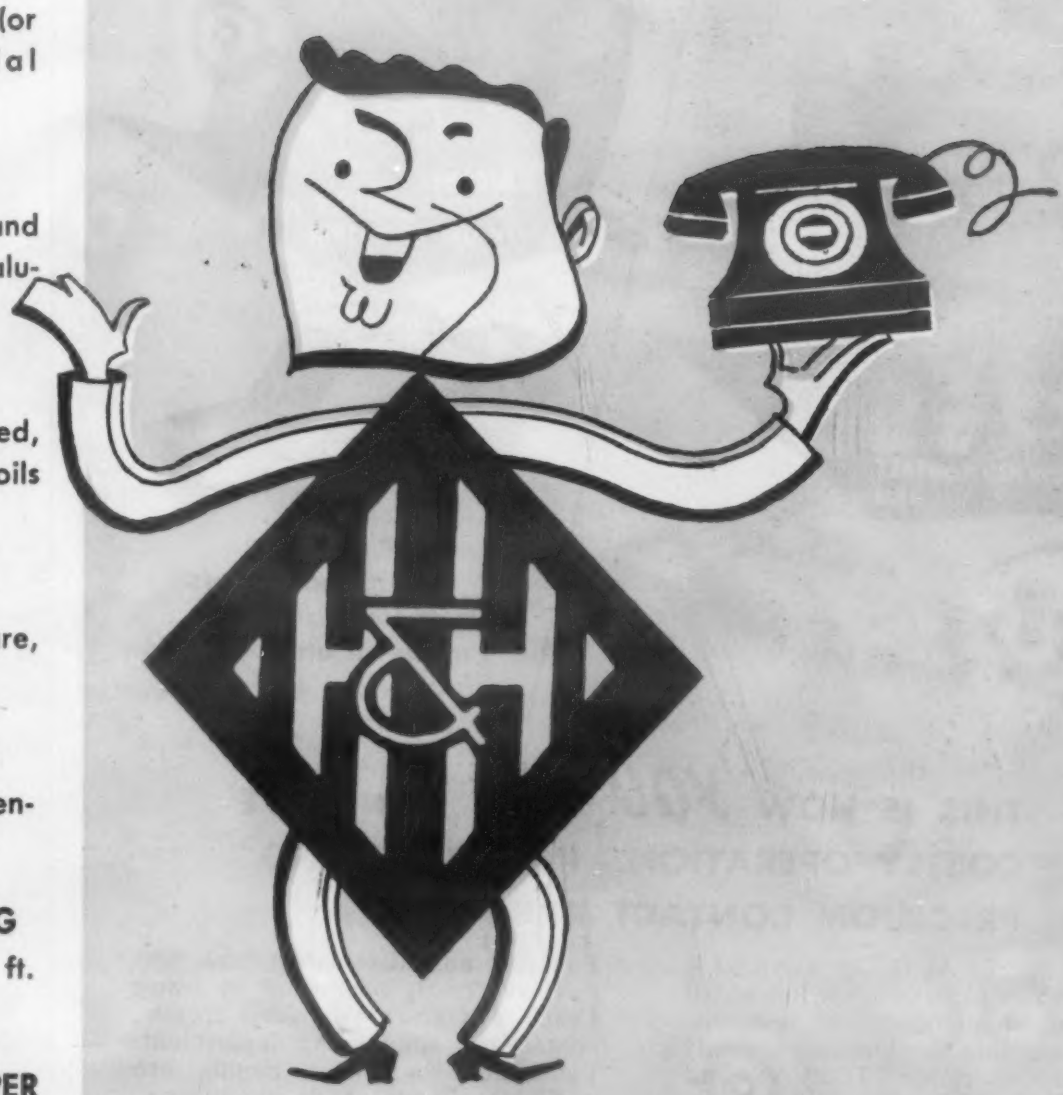
STRAIGHT LENGTHS
Seamless round, square, rectangular

COILED COPPER TUBE
For automotive and general use, 25 ft. coils

COPPER WATER TUBING
60 ft. coils and 20 ft. straight lengths

STRIP BRASS AND COPPER
Any width up to 7 inches, thickness .0159 and lighter, also solder coated if desired



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Will Laminated Metals Save Operations for You?

OLD WAY
BRASS STRIP
BLANKED PIERCED FORMED INTO THIS . . .
ADD CONTACT DISC AND BRAZE
BECOMES FINISHED CONTACT ARM
THIS WAS MADE IN 3 STEPS
NEW WAY
LEACH & GARNER TOP-LAY STOCK . . .
. . . BECOMES FINISHED CONTACT ARM IN ONE OPERATION
. . . By using Leach & Garner laminated metals this contact arm was made in one operation —blank piece and form.

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By using LEACH & GARNER TOPLAY, a form of silver laminated material, many electrical manufacturers are able to eliminate a costly assembly operation. TOPLAY and other forms of laminated metals are regularly used by leading manufacturers in the industry. Fifty years experience in producing precious metals in solid and laminated mill forms enables us to answer your problems of dimensional tolerance, finish, or alloy composition and properties.
Maintaining high quality and making prompt deliveries at competitive prices for our many customers (leaders in the electrical industry) is proof of our ability to serve you.

For recommendations on how you can save costly operations by using Leach & Garner laminated metals, contact our engineering department. Laminated and solid metals are available in sheet, wire and tubing.
WE BUILD OUR BUSINESS ON PROMPT DELIVERIES AT COMPETITIVE PRICES.

Fabricated precious metal parts available from our affiliate, GENERAL FINDINGS & SUPPLY CO., Attleboro, Mass.

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CONTENTS NOTED

400 F. Hot strength of SAP decreases only slightly. Room temperature properties of SAP are unaffected even by holding for two years at temperatures up to 570 F.

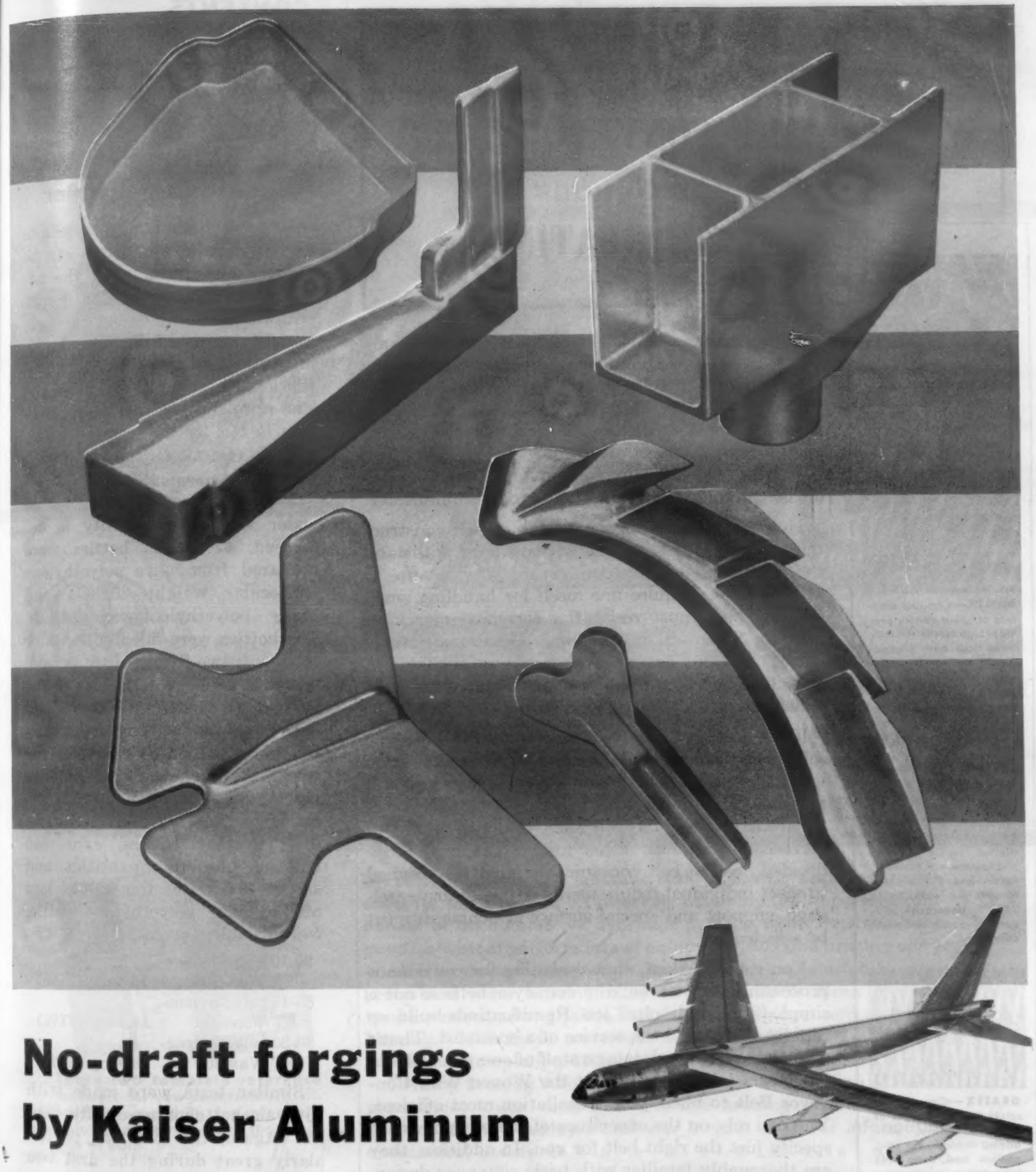
Titanium has recently been featured for applications involving temperatures of 400 to 950 F. When the difference in specific weight is considered, titanium and SAP have similar hot strengths up to about 1100 F, although specific strength of the titanium is higher than that of the SAP. On the basis of stress-rupture strength per unit density at 900 F, SAP exceeds titanium for periods greater than 10 hr. (Experimental titanium alloys not yet on the market show higher strengths than the commercial alloys used for this comparison.)

Naturally, the creep strength and hot fatigue strength of SAP are higher than those of all precipitation-hardened aluminum alloys. In practice, SAP is of interest mainly for its properties at temperatures over 480 F.

The high hot strength of SAP necessitates unusually high forming pressures. Aluminum powder is first cold pressed, then hot pressed and sintered, and finally extruded or again hot pressed into bars. Bars can be forged or pressed to semifinished products, and sheet bar can be hot or cold rolled to sheet. Although an oxide content of about 13.5% is best for forged parts, an oxide content of 11% is preferred for sheet.

In reviewing the entire development of SAP, the author says that one of the first needs was to obtain the finest powder possible, since strength increases with decreasing particle size. Attempts to use electrolytic or atomized powder, which would be cheaper than Hametag powder, were unsuccessful because of inadequate strength. Alloyed aluminum powder showed no advantages over pure aluminum powder because of the high diffusivity rate of foreign metals in SAP.

(more Contents Noted on p 206)



No-draft forgings by Kaiser Aluminum

KAISER ALUMINUM'S Erie plant has been successful in meeting its customers' ever-growing needs for no-draft forgings.

Shown on this page are a few of the many no-draft forgings produced by Kaiser Aluminum on *existing equipment* for the aircraft industry.

Additional equipment—especially designed for no-draft forgings—will soon be installed to greatly increase our capacity for these specialized forgings.

Kaiser Aluminum no-draft forgings give you the benefits of substantial cost savings through the elimination of machining, plus extremely light weight with high strength, close tolerances, and superior finish.

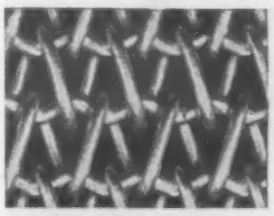
When you submit your aluminum forging inquiry to Kaiser Aluminum, our highly skilled engineering staff will evaluate the forging to determine its suitability as a no-draft forging.

For immediate service, call any Kaiser Aluminum sales office listed in your local telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Building, Chicago 11, Illinois; *Executive Office,* Kaiser Building, Oakland 12, California.

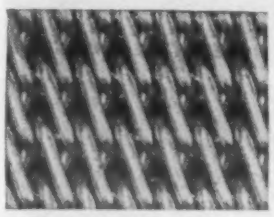
Kaiser Aluminum

For more information, turn to Reader Service Card, Circle No. 514

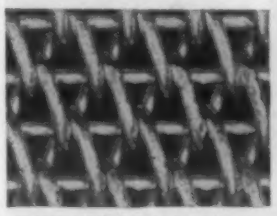
How to select WOVEN WIRE CONVEYOR BELTS for Continuous HEAT TREATING



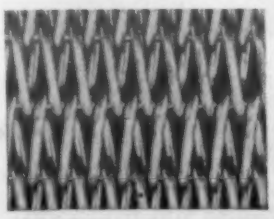
BALANCED—High tensile strength, low ultimate cost belting for operation up to 1300°F. Resists distortion. Designed for straight travel.



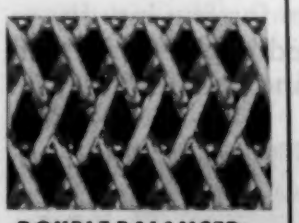
DUPLEX—Compact structure of great density provides high tensile strength, while close mesh provides smooth surface for carrying small parts.



ROD-REINFORCED—Highest tensile strength and low thermal capacity. Recommended for high temperature work, up to 2100°F. Undergoes minimum elongation and width contraction.



GRATEX—Close spirals retain the advantages of Balanced weave, while adding strength. For cold, medium and some high temperature applications.



DOUBLE BALANCED—A widely used weave combining open mesh of Balanced Weave with the strength of Gratex. For cold, medium and some high temperature applications.

As you know, woven wire conveyor belts are widely used for combining movement with processing in many continuous metalworking operations—brazing, annealing, sintering, quenching, tempering, washing, etc. Heat treaters, particularly, find that in all phases of their operations, belt-to-belt flow through processing eliminates manual handling, increases production efficiency and product uniformity.

However, there is no single type of belt construction suitable for all operations. Some must withstand the rigors of higher temperature service—up to 2100°F.; some require fine mesh for handling small parts; others must resist the corrosive attack of pickling processes and cooling operations. That's why Cambridge has nine basic weaves available in any metal or alloy. The five shown here are the most widely used in the metalworking industry.

There are several factors that generally influence selection of weave, mesh size and metal or alloy from which the belt will be woven. Among them are: size and shape of the parts to be handled, temperatures to which belt will be subjected, presence of wet or corrosive conditions. Even after these have been decided, overall belt construction must be designed to meet individual requirements—type of drive, selvage, support and special surface attachments must be selected.

You can see, then, that designing for continuous processing with woven wire conveyor belts is not a simple "nuts and bolts" job. Ramifications build up rapidly to demand the service of a specialist. That's why Cambridge maintains a staff of competent Field Engineers to help you select the Woven Wire Conveyor Belt to make your installation most efficient. You can rely on the experience of these engineers to specify just the right belt for you. In addition, they are thoroughly familiar with basic conveyor design. For the name of your nearest Cambridge Field Engineer, look under "Belting, Mechanical" in your classified telephone book. Or, write direct. Also ask for Special Report, "6 WAYS to Increase HEAT TREATING PRODUCTION", and 130-page Reference Manual of specifications and design information. THE CAMBRIDGE WIRE CLOTH CO., DEPARTMENT A, CAMBRIDGE 9, MD.

Polyethylene Plus Wax Makes Better Barrier

Permeability of polyethylene to various liquids and gases can be reduced substantially by the addition of high melting, hard mineral waxes. Stiffness and hardness are also increased. Results of adding 10-20% of these waxes to conventional high pressure polyethylene were reported by Dr. G. Benthin in No. 3, 1956 issue of *Kunststoffe* (German).

Decreased permeability

To determine to what degree water vapor permeability is decreased, 47 cu cm bottles were prepared from pure polyethylene (molecular weight 20,000) and three polyethylene-wax blends. The bottles were filled with water to about two-fifths capacity and stored at 79 F. Weight loss of the individual bottles, determined daily, was particularly great during the first two days. After six weeks' storage, weight of the pure polyethylene bottle had been reduced by 20.8 mg. Weight losses of the other bottles, expressed both as absolute quantities and as percentages of the weight loss of the pure polyethylene bottle, were as follows:

90-10 polyethylene-FT Wax-300	16.8 mg (77%)
85-15 polyethylene-FT Wax-300	14.8 mg (71%)
80-20 polyethylene-FT Wax-300	13.9 mg (66%)

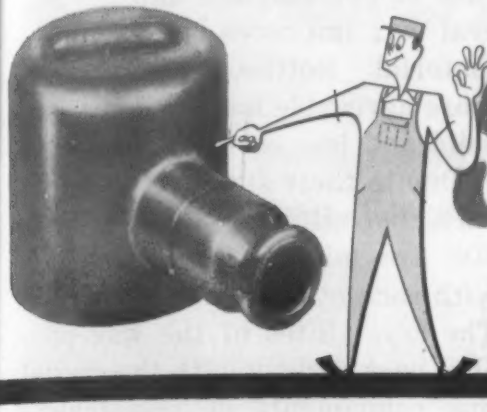
Similar tests were made with 95% alcohol denatured with benzol. Again, the loss was particularly great during the first two days. In the days following, up to an indefinite storage period, weight losses of the three blend bottles were 67, 59.7 and 58% respectively, of the weight loss of the pure polyethylene bottle. Thus, permeability of polyethylene to alcohol vapor is decreased even more noticeably than permeability to water vapor.

Further tests indicated that the blends substantially reduced gas transmission rates for hydrogen

For more information, turn to Reader Service Card, Circle No. 375

BRAZED SUCCESSFULLY WITH... SILVALOY

LOW TEMPERATURE SILVER BRAZING ALLOY



This is the trade mark of Brochu and Hass of Grand Rapids, Michigan—one of the more successful manufacturers in the field of forming and assembling stampings in steel, brass and aluminum for automotive, household appliance and specialty hardware manufacturers.

These two complete reference manuals for low temperature silver brazing and fluxing are available upon request. Send for either one or both.

An efficient production schedule such as Brochu and Hass developed for this stamped oil reservoir assembly (an important component of an automotive hydraulic pump system) depends upon good, consistent performance of equipment, flux and brazing alloy.

After much experimentation, Brochu and Hass selected Silvaloy preformed silver brazing alloy rings and APW Black Flux "to insure perfect, strong joints and to avoid 'leakers' and costly re-brazing." With these materials, their specially built machine is capable of completing 300 to 400 units per hour.

Silvaloy Brazing Alloys and APW Fluxes are helping to speed production, lower costs and improve brazing results in many fields. Call the Silvaloy Distributor in your area for information or technical assistance. ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

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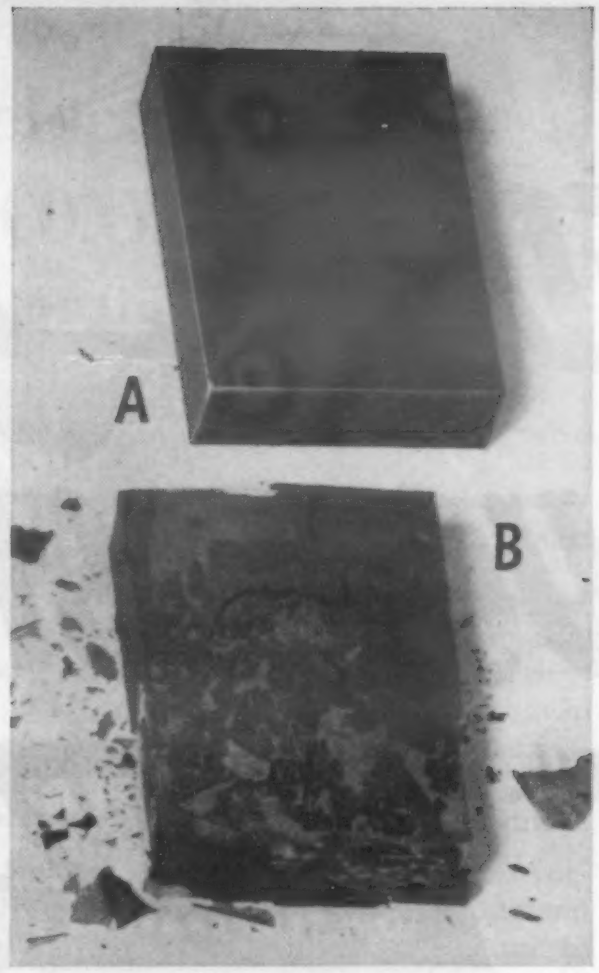
KENTANIUM*

unharmed at 2000°F while → heat-resistant nickel-chrome alloy disintegrates



(Photo A) Kentanium shows only slight oxidation after test and is good for many more hours' exposure at 2000°F. (Photo B) Hard nickel-chromium (35%) alloy is badly oxidized and began to disintegrate during test.

Exceptional resistance to oxidation, combined with great strength at very high temperatures, are characteristics of Kentanium, a titanium carbide composition. Here's proof.

A square of K161B Kentanium and a similar square of a well-known, heat-resistant 35 chromium-15 nickel alloy were exposed for 120 hours in an unsealed muffle furnace heated to 2000°F. The accompanying photographs vividly show how each piece was affected. While Kentanium is still good for hours of exposure at high temperatures, the nickel-chrome alloy has oxidized badly and has begun to disintegrate.

This demonstration suggests how well Kentanium will perform in such applications as furnace parts, heat-treating fixtures, quench guide rings, turbine blades, nozzle vanes, bushings and other parts where strength at high temperature, plus high resistance to oxidation, are factors.

Parts illustrated above are typical applications of Kentanium. The Kentanium series represents only a part of Kennametal's wide range of hard carbide compositions that are helping designers who require metals offering high resistance to abrasion, deflection, deformation, impact or corrosion. Perhaps one or more of these Kennametal compositions will help you get your idea off the drawing board into production. These materials are described and many applications discussed in two booklets: B-111-A—"Characteristics of Kennametal," and B-222—"Designing with Kennametal."

Write KENNAMETAL INC., Latrobe, Pa.

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INDUSTRY AND KENNAMETAL ...Partners in Progress

and carbon dioxide. Also, additions of wax improve polyethylene as an odor barrier.

Higher rigidity

The combined crystalline structure of polyethylene and the mineral wax improves rigidity of the material. Bottles have a harder, more agreeable hand and are more solid and less easily compressible.

Due to their similarity in structure, polyethylene and FT Wax-300 are miscible and compatible with each other in any proportion. The crystallites of the wax probably pack tightly with the crystalline components of polyethylene, eliminating the danger of a separation of the mixture on aging.

Titanium Coatings for Copper, Iron, Steel

Thick, corrosion resistant coatings of titanium on copper, ingot iron, mild steels and other metals can be obtained by processing under an inert gas in fused salt baths containing titanium-oxygen alloys high in titanium content. Details of the process were described by S. T. Shih, M. E. Straumanis and A. W. Schlechten in the July issue of *Journal of the Electrochemical Society*.

Objects to be coated are embedded in a mixture of sodium or potassium chloride and the titanium-oxygen alloy, then heated in helium for several hours at about 1560 F (copper) or 1830 F (iron and mild steel). Coating thickness depends primarily on temperature and secondarily on time, oxygen content of the alloy and bath temperature. High temperatures and longer coating times are preferred. The same bath can be used repeatedly.

Ingot iron samples are coated to about 0.0006 in. at 1830 F in 4 hr. Including the diffusion layer, the thickness of the whole layer is about 0.0051 in. The titanium coating is harder than the core and is quite adherent under rea-

(continued on p 213)

For more information, turn to Reader Service Card, Circle No. 547

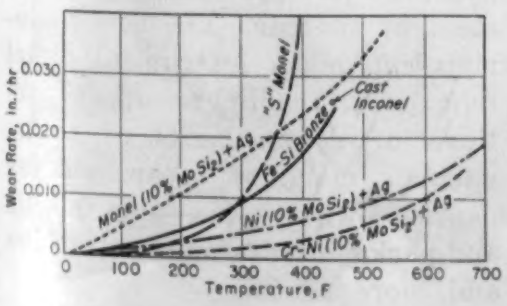
sonable stresses. Deformation within elasticity limits does not affect coating quality. However, when the base metal is deformed beyond its elastic limit there is a tendency for the coating to develop cracks and checks and to flake off.

New Alloys Developed for Hot Bearing Cages

Present cage materials in the rolling contact bearings used to support rotors in military aircraft gas turbines appear to be operating at their upper temperature limits with no safety margin. Although the mechanism of cage failure is not known exactly, adhesive metal transfer between cage and race materials seems to play a major role. Therefore, selection of retainer materials must be based on their frictional characteristics and surface stability against hardened steel.

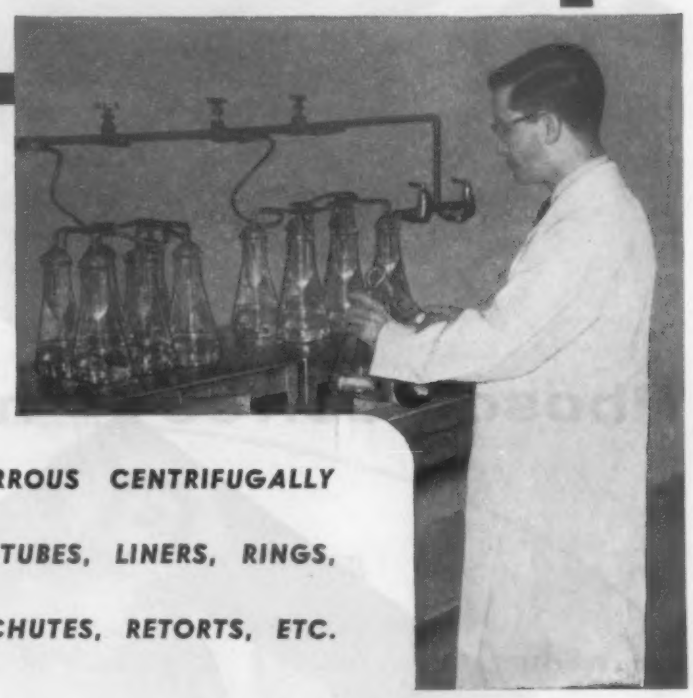
The most satisfactory cage materials now in use are silver plated iron-silicon bronze and silver plated "S" Monel. Working on the premise that a combination of hard and soft phases would be superior for cages to withstand the conditions, F. C. Wagner and J. T. Burwell, Jr., of Horizons, Inc., determined the properties of a number of new alloys. They reported the results of their investigations at the annual meeting of the American Society of Lubrication Engineers in April.

With silver as the major constituent, several alloy compositions have been developed that have elevated temperature wear



Wear rates *of infiltrated metal powder cage materials as a function of temperature.*

To Rely on SANDUSKY Is to Rely on Research



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Add to this research the right materials and consistent control and the result is a ferrous or non-ferrous casting which will do its specific job while resisting heat, abrasion, and corrosion as required. An additional service is machining facilities for turning, boring, and drilling.

Rely on Chief Sandusky as an organization of specialists with the answers to your problems with the finest of centrifugal castings.

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FERROUS AND NON-FERROUS

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Everyday . . . this leading *manufacturer PHOSON brazes over 5400 hard to see and reach copper joints. Even though hidden deep down in air conditioning unit assemblies, "leaker" rejections are less than ½ of 1%!

High capillary attraction at low temperature, without flux, make United's Phoson 6 perfect for such tough "in close" brazing jobs.

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For all types of hand fed or automatic copper brazing, Phoson 6 has every desirable characteristic you want . . . high capillary attraction, lowest possible brazing temperature, greatest resistance to vibration and lowest possible cost.

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resistance superior to that of the standard alloys mentioned. As long as silver is contained in the soft matrix, alloy composition of the strong load-supporting phase can be varied considerably. Promising results have been obtained with nickel base alloys formed by powder metallurgy techniques, with cast alloys containing copper and aluminum, and with tungsten carbide. Addition of 2 to 4% silicon to the nickel phase is distinctly beneficial to the wear properties of several classes of alloys.

Wear rates of several promising silver-impregnated nickel alloy powder compacts are compared with those of iron-silicon bronze and "S" Monel in the accompanying graph.

Selecting Materials for Car Interiors

Car manufacturers have learned the hard way that progressive design sells cars. Therefore, the automotive industry has been particularly alert to adapt new engineering materials to new designs with emphasis on both style and function. The impact of some of the new polymeric materials on the design of car interiors was discussed in several papers delivered before the Passenger Car Body and Materials Meeting of the Society of Automotive Engineers last March.

Plastics sheet

Developments in plastics materials in recent years have released the designer of auto interiors from the traditional cut and sew practices in use since the development of the car. The new materials can make instrument panel trim pads, headliners, upper portions of doors, backs of seats, garnish moldings, rear quarter panels, cowl kick, seat side shields and package trays more attractive and more useful.

T. R. Grimes of U. S. Rubber itemized the general requirements for an automotive interior trim

Your *Best* *Choice!*

COPPER

HUSSEY

BRASS

Sheet
Wire
Coils
Rod
Strip
Tubing
Roofing
Products

- Manufactured by a company with over 100 years experience in producing copper and brass products of quality.
- Produced in the form your job requires and easily fabricated to your design.
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Please send complete specification data
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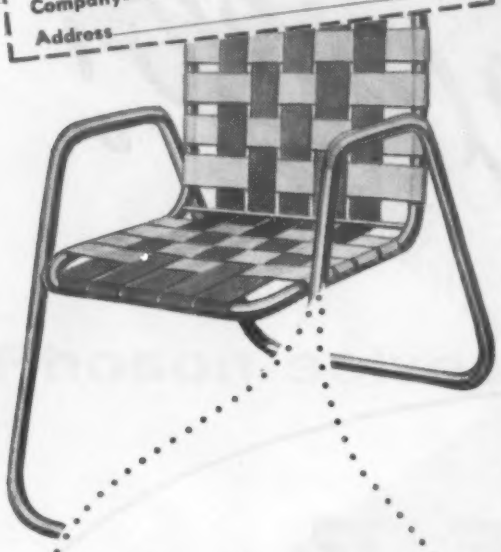

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Aluminum
Fastener
should be
used here!

It's an aluminum chair assembly, worth the lasting strength of Alcoa® Aluminum Fasteners. You avoid galvanic and atmospheric corrosion. You get perfect color match; you get the very highest quality product. Your local Alcoa distributor has a complete stock.

P.S. For this chair assembly, we suggest an aluminum machine screw, washer and nut from Alcoa's complete line of aluminum fasteners.

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YOUR GUIDE TO
THE BEST IN
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ALCOA ALUMINUM FASTENERS

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CONTENTS NOTED

material as: 1) Flexibility of design—Ability to attain variety of shapes, finishes and colors; 2) Serviceability—Ability to retain color fastness and finish for life of the car, despite extremes of heat and cold and sunlight; 3) Compatibility—Ability to be used with and joined to other materials; 4) Economy—Costs must be low enough to meet practical limits on car price; 5) Availability—To become a prime material it must be readily available to the manufacturer.

In his discussion of formable plastics sheet, Mr. Grimes points out how a modified styrene material (Royalite) measures up to these requirements.

Flexibility of design — Many types of surface treatments can be applied:

1. Surface grains. Grains can be produced to duplicate practically any finish desired, including a number of fabrics.

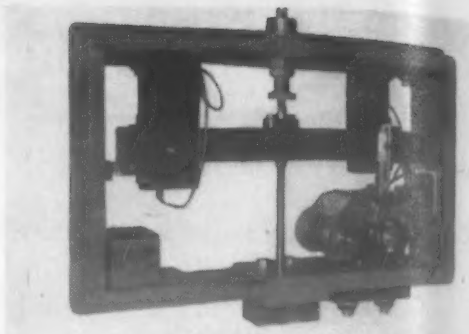
2. Two tones and prints. Two colors can be combined by means of commercial two-toning and shade-wiping equipment. The process involves partial filling of solid colored grained surfaces with a contrasting color ink. Two-tone color effects can also be obtained with conventional printing equipment used in the coated fabrics industry, or by conventional silk screening methods.

3. Solvent lacquer treatments. Any limitation on color of the base compound can be overcome by lacquering the exact color desired over a similar colored base.

4. Vacuum metallizing. Royalite can be vacuum metallized in the same manner as other commercial plastics.

5. Plastics film combinations. New surface effects can be obtained by combining formed parts with various commercial metallized plastics films.

Making design possibilities even more flexible is the susceptibility of the thermoplastic sheet to a wide variety of configurations. The range of shapes possible is



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Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington and Dover, N. J.
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
DeLaval Steam Turbine Co., Trenton, N. J.
Empire Pattern & Foundry Co., Tulsa, Okla.
Farrel-Birmingham Co., Inc., Ansonia, Conn.
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machine Co., Inc., Cleveland, Ohio
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Rosedale Foundry & Machine Co., Pittsburgh, Pa.
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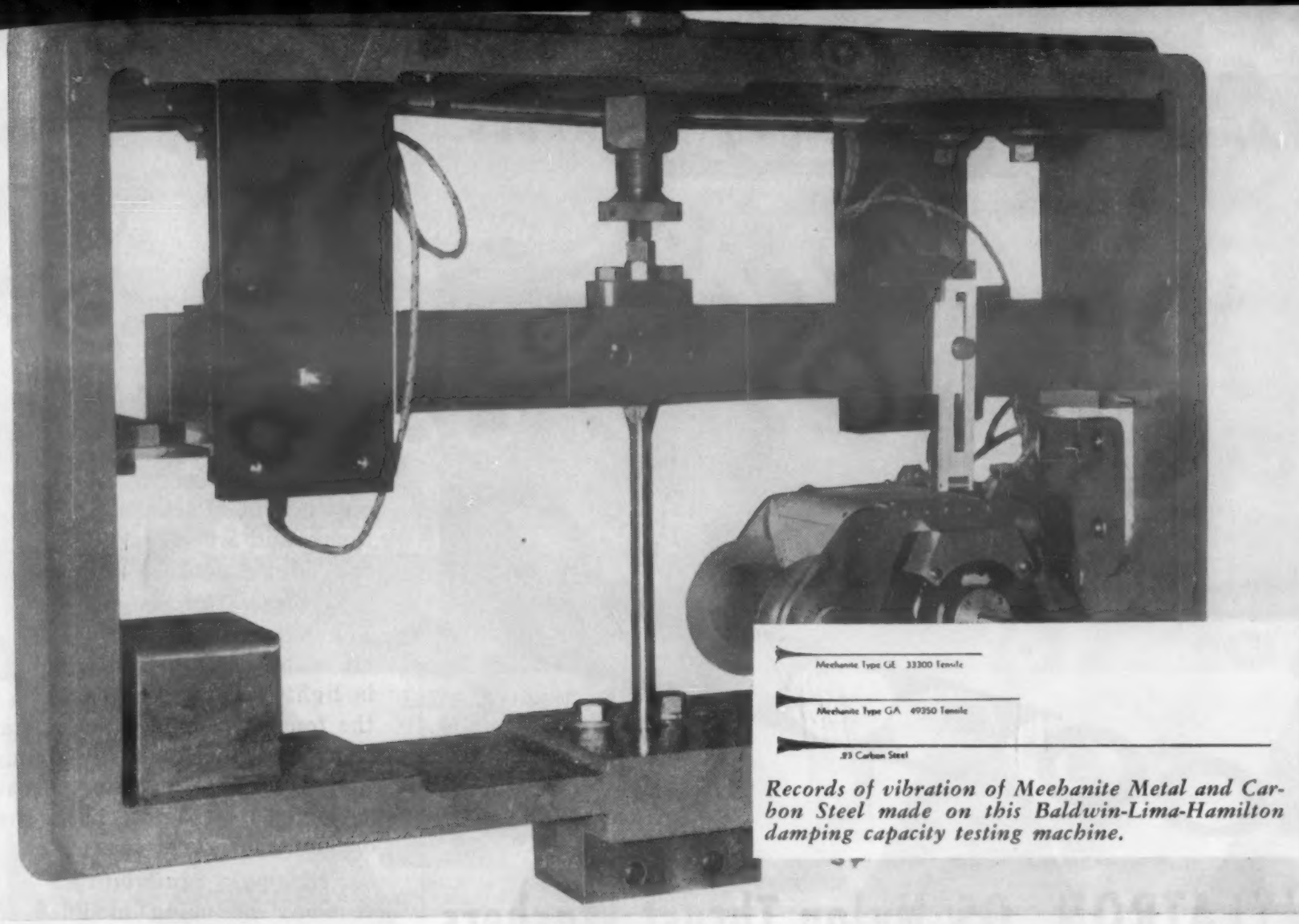
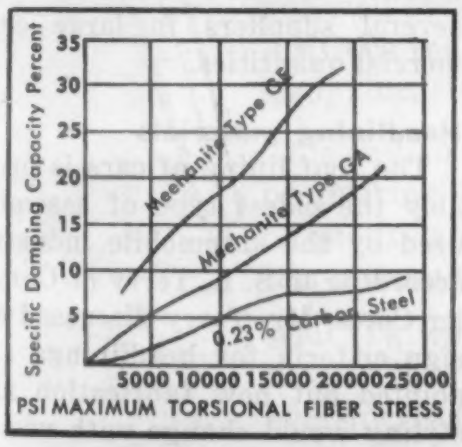


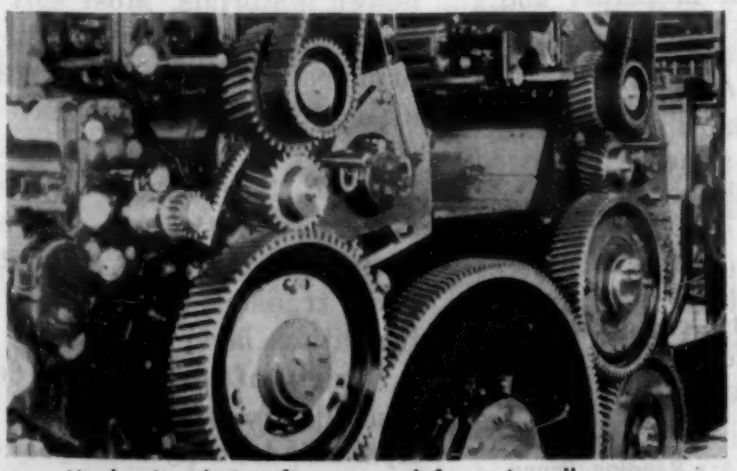
Records of vibration of Meehanite Metal and Carbon Steel made on this Baldwin-Lima-Hamilton damping capacity testing machine.

MEEHANITE CASTINGS POSSESS SUPERIOR VIBRATION DAMPING PROPERTIES AT HIGH STRESS RANGES

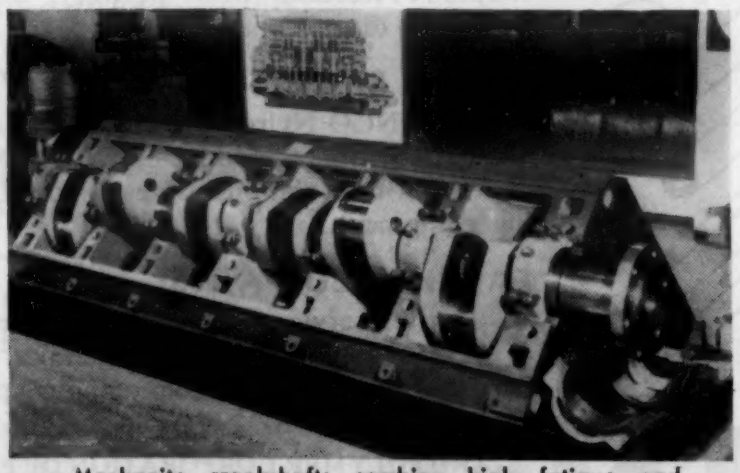


Extreme accuracy in precision machinery and high fatigue life of repeatedly stressed machined parts can be assured with Meehanite Metal castings. Uniform graphite distribution in Meehanite castings provides high damping capacity — 3 times that of steel — (see graph) to absorb built-up stresses due to vibrations. A wholly pearlitic base structure provides the necessary high strength and wear resistance.

Combining the best features of cast iron and steel with other engineered properties, Meehanite castings are uniformly solid and dense, free from defects and readily machinable.



Meehanite chain of gears and fountain rolls assure perfect register and minimum friction and noise in high speed printing operations.



Meehanite crankshafts combine high fatigue and wear resisting properties with excellent damping qualities that reduce resonant vibrations and provide smoother engine performance.

MEEHANITE METAL®

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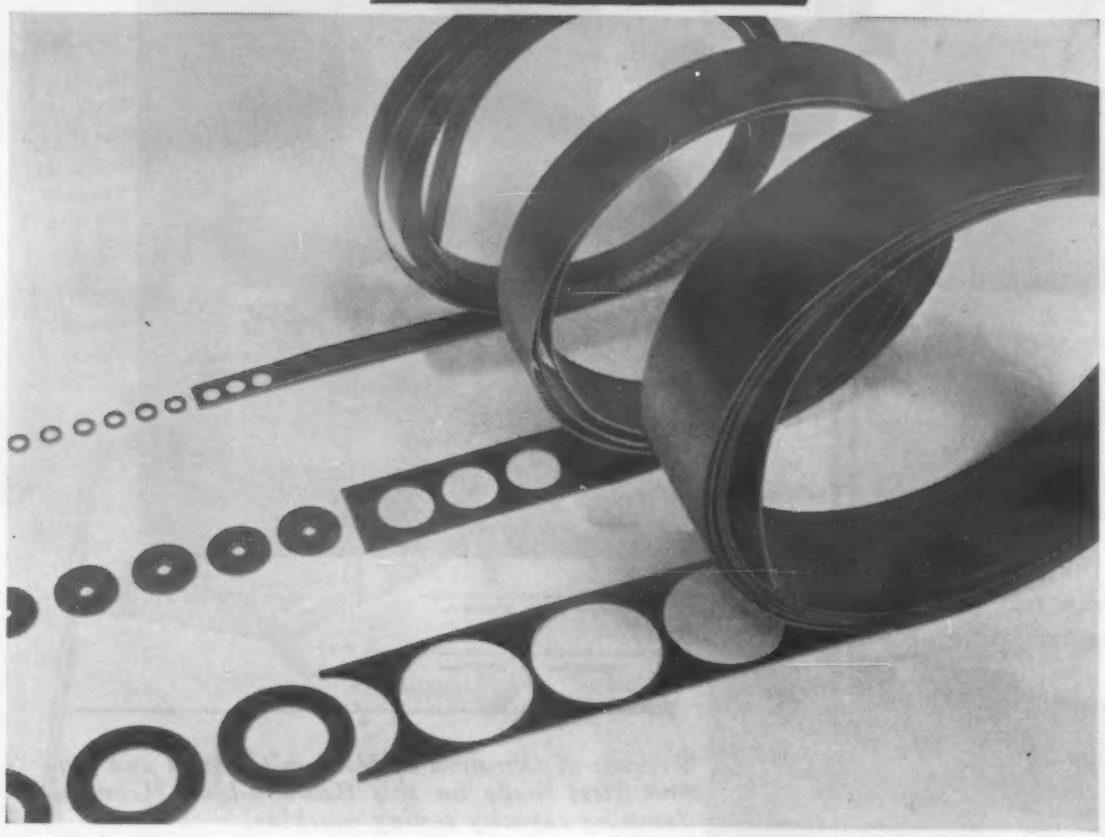
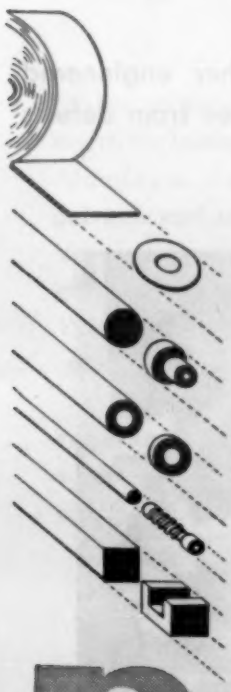
POLYPENCO® NYLON SHAPES



NYLATRON® GS Nylon Thrust Washers

Resist Wear • Reduce Noise
Provide Smooth Operation Without Lubrication

NYLATRON GS Nylon thrust washers—rapidly stamped from coiled strip—outlast other materials wherever there are thrust loads between metal parts—such as in fractional horsepower motors.



NYLATRON GS:
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You can expect highest quality nylon with POLYPENCO stock shapes . . . freedom from porosity, uniform properties and maximum dimensional stability.

STOCK SHAPES READILY AVAILABLE:
POLYPENCO Nylon stock shapes are available in rod, strip, tubular bar, tubing and slab. POLYPENCO standard and special nylon formulations are easily machinable on metalworking equipment.

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Fabrication service is available for your parts—engineered for the best in design, quality and tolerance. Write to the Technical Service Department for help on your application.

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POLYPENCO Nylon, Teflon†, Q-200.5 (cross-linked polystyrene) and K-51 (chlorinated polymer)

*PATENTS APPLIED FOR
†DU PONT TRADEMARK

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illustrated by some of the applications for which it has already been used successfully. They include seat side shields in General Motors cars, center pillar covers for '55 and '56 four-door hardtop models, instrument panel trim on '56 Studebakers, door trim pads on the '56 Packard, and headliners and wheelhouse covers for the '56 Plymouth.

Serviceability, compatibility — The material is resistant to grease, oil, water, mildew and vermin. It is lightweight, odorless, warm to the touch, washable and resistant to most alkalies and acids. Though it is not resistant to aromatic solvents, it is resistant to most organic materials.

Economy, availability — The economy of using modified styrene materials is often concealed in labor savings resulting from combining operations into one vacuum forming step on relatively inexpensive tooling. Nitrile gum plastics are now available from several suppliers in large commercial quantities.

Headlining materials

The roof lining of cars is probably the oldest type of assembly used by the automobile industry, according to S. L. Terry of Chrysler Corp. Mr. Terry discussed design criteria for headlinings and pointed out how fabrication and styling would change with use of newer materials. Most soft headlining materials are still made principally of cotton. In general, all cotton headlinings have good seam strength, tear strength and "cover." They also have the necessary quality of irreversible shrinkage and they all satisfactorily transmit sound to the sound insulation layer under the roof. A variety of textures and designs is available, and cost is low. Principal disadvantages are poor cleanability and a tendency to wick and stain.

After outlining the design needs for headlinings, Mr. Terry discussed various newer materials and how they may be used for

with quality and dependability as bywords . . .

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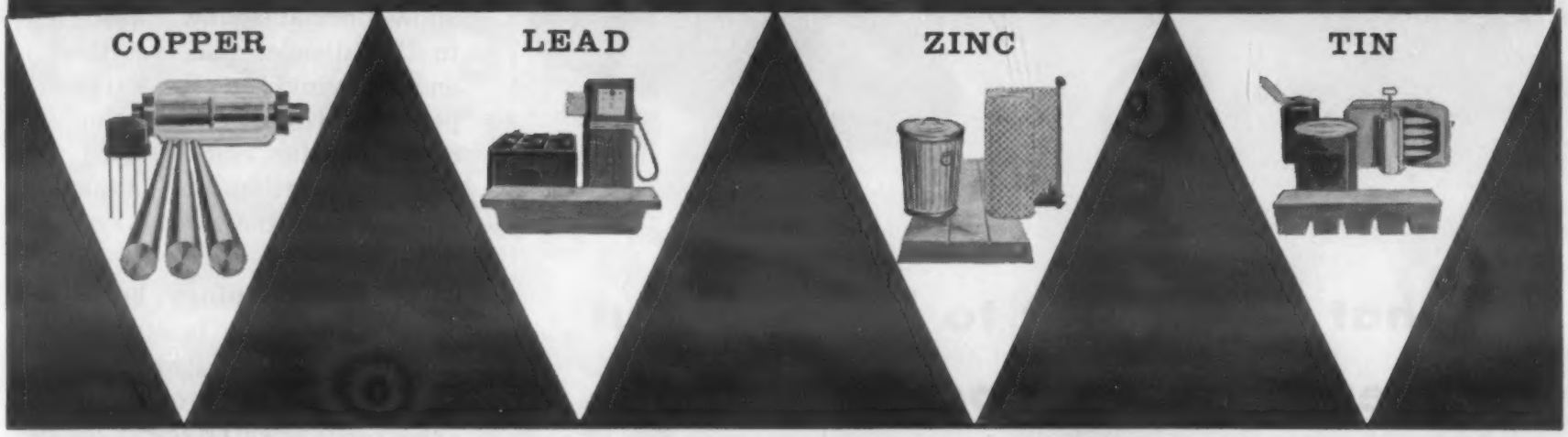

For well over half a century, American Industry has found AMCO a reliable and dependable source of high-quality copper, lead, zinc, tin, and other non-ferrous metals.

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AMCO's world-wide resources assure an uninterrupted flow of raw materials with which to supply Industry's ever-increasing demands for "specification" metals.

Outstanding examples of AMCO's success in meeting Industry's requirements are:

OFHC®– Oxygen-free, high-conductivity copper of highest purity, developed expressly for electronics applications

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For further information on these and other AMCO products, please contact the Metal Sales Department–

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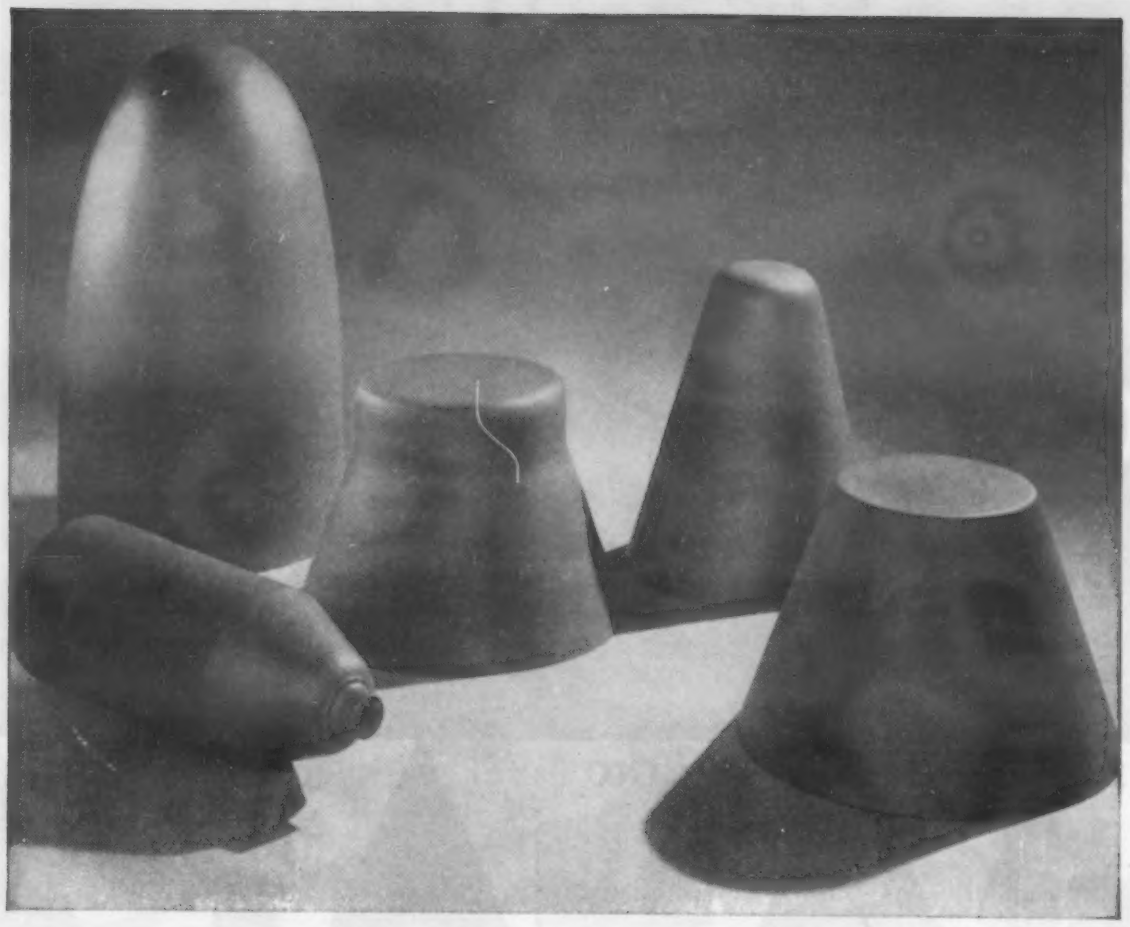

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Hackney deep drawn shapes and shells permit product designers to reduce weight, save production time and lower unit costs—improve product appearance, increase strength and vibration resistance. Our experience in producing O.E.M. parts for manufacturers of many types of equipment can help you achieve similar results. Just keep these basic specifications in mind:

Shapes: Cylindrical, spherical, tapered or conical.

Capacities: From 1 quart to 70 gallons.

Diameters: From 3 inches up to 32 inches.

Depths: Up to 60 inches. Two half shells are easily welded together for extra length or symmetrical design. Open end can be closed by spinning to give an entirely seamless cylinder.

Blank thicknesses: 16 gauge and heavier.

Wall thickness: For working pressures up to 5,000 psi in the smaller diameters—up to 200 psi in the larger diameters.

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headlinings in the future.

Conventional vinyl headlinings are somewhat unsatisfactory because they do not transmit high frequency sound vibrations to the roof silencer. Perforations can correct this situation, but conventional perforated vinyl costs approximately 20% more than standard supported vinyl. A new type of supported vinyl is now available which appears to have promise. It is porous enough to allow normal sound transmission to the silencer pad, yet there is enough vinyl on the surface to permit satisfactory cleaning. An over-all print can be used with this construction to hide the holes that provide the necessary porosity.

Paper headlinings have been used, particularly in station wagons. Cost of paper compares favorably with that of cotton, and appearance is satisfactory for specialized applications. However, paper is difficult to trim because it does not shrink. Also it does not have the desirable pliability and elastic characteristics. Polyvinylidene chloride (Saran) has also been used, but its cost is high.

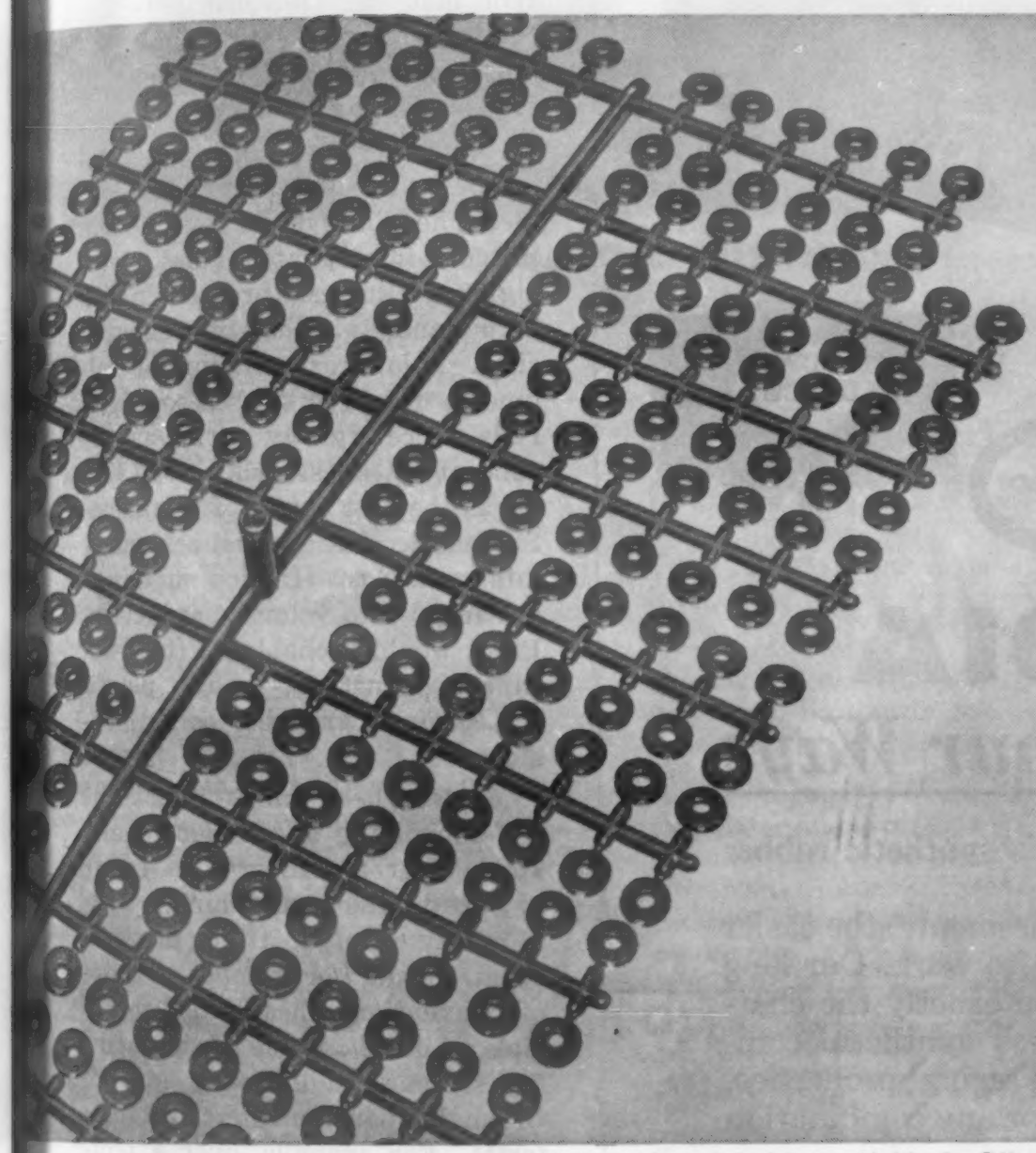
Quality napped materials are often specified for luxury cars. They do not soil as readily as 100% cotton and they look better, though they are approximately 50% more expensive than all-cotton headlinings. Wool headlinings have improved cleanability and soiling characteristics, but they cost about four times more than cotton.

One-piece headlinings

The method of installing headlinings will change drastically in the near future, according to Mr. Terry. With labor costs rising, automobile engineers and stylists are simplifying their designs so that pieces can be made in fewer operations with less hand labor. By using some of the newer materials it is highly likely that it will be possible to mold a headlining assemby as one piece and

With **TENITE POLYETHYLENE**

300 seals for dry cells can be made in one shot



Washers of Tenite Polyethylene molded for Ray-O-Vac Company by Evans-Zeier Plastic Company, both of Madison, Wisconsin

Every day sees new uses develop for Tenite Polyethylene. Here's one that's cutting costs and simplifying assembly procedures for a leading manufacturer of dry cell batteries.

Formerly, dry cells were finished by pouring molten pitch around the carbon anode to seal the open end. But look how Ray-O-Vac speeds this operation. A molded Tenite Polyethylene washer is force-fitted over the carbon rod and the metal edges of the cell are then crimped into the washer. Result: a water-tight seal, no electrical leakage, and faster production.

Design of the individual washers was no problem. But the design of the mold itself was. For collectively, 300 washers in one shot represented quite an intricate molding. Needed was a plastic that flowed easily at normal molding temperatures to completely fill every one of the 300 tiny mold cavities. Small wonder, then, that Tenite Polyethylene was the plastic chosen by the molder of these washers.

This Eastman plastic has exceptionally good molding properties. Its fast, even flow permits use of more complicated molds than were ever before practicable with Polyethylene. Investigate for yourself the production economies that may result through use of easy-to-mold Tenite Polyethylene. Investigate, too, the ability of this plastic to add longer life, better performance or greater sales appeal to some product you make. For more information about this versatile plastic, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

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install it as a unit. Such a headlining is now being used in the Plymouth Suburban. It is made of a vacuum formed modified styrene material (Royalite). It has the texture and color of vinyl, has ribs molded in and is completely self-supporting.

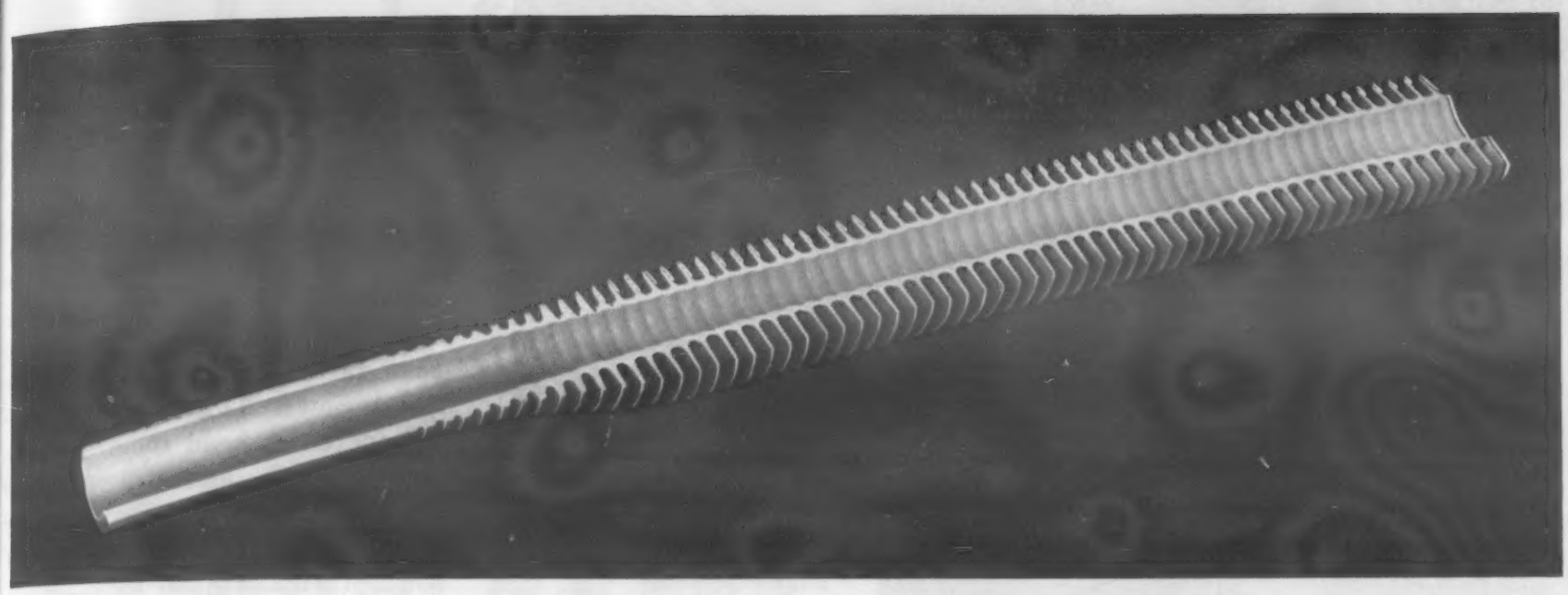
A number of other materials are being considered for such one-piece headlinings. They include phenolic-impregnated glass cloth, rigid urethanes, pressed paper pulp and phenolic-impregnated sisal. A low cost per unit of volume is required for these materials, since rigidity varies as the cube of thickness, while cost varies as the first power of thickness. Surface decoration must be done at minimum cost if such moldings are to go into volume production. Paint would probably be the least expensive method, though plastisol coatings are also being considered.

Molded headlinings must be self-supporting and dimensionally stable over a temperature range of —20 to 180 F and during wide humidity changes. Other physical requirements correspond to those of conventional headlining materials. A disadvantage of the modified styrene headliners is the high thermal expansion rate of the material. For example, over a temperature change of 200 F, a Royalite headlining expands approximately ¾ in. more across the car than the steel roof panel.

Another type of headlining is being used in limited production. It consists of about four or six panels of 0.080-in. thick, untempered Masonite. Panels are individually self-supporting and are

New Silicon Carbide
Coming in October

A new type of silicon carbide has unusually high thermal conductivity, low thermal expansion and much better strength at high temperatures than existing types. This article gives detailed properties.



WOLVERINE TRUFIN® The Integral Finned Tube

Wolverine Trufin —Big Step Forward in Heat Transfer

Probably the most significant advance in heat transfer applications came with Wolverine Tube's development of Wolverine Trufin—the integral finned condenser tube.

Trufin is an extended surface tube with fins squeezed directly from the tube wall. Because of this it has more than twice the heat transfer surface of plain tube—extracts more BTU's per foot of tube.

Wolverine Trufin is available in aluminum as well as in copper, copper-base alloys and electric-welded steel. Because its fins are actually part of the tube wall they are unaffected by vibration, temperature changes or pressure variations.

Trufin is available in five distinct types with fins varying in height and number per inch. High finned aluminum Trufin is particularly effective in air-cooled heat transfer applications.

FREE CATALOG BIG HELP TO MANUFACTURERS

A complete description of Wolverine Tube's product line and fabrication facilities is contained in the General Products Catalog. Your request will start it on its way to you without any obligation. Write today!

New Trends Noted:

ALUMINUM TAKES NEW FORM IN WOLVERINE FABRICATION

Today, wherever aluminum is used in the metalworking industry, a new trend is becoming increasingly apparent.

By using the fabrication facilities of supplier firms like Wolverine Tube, many aluminum manufacturers are reducing their production operations and releasing manpower, floor space and equipment for other duties. The net result is a definite saving in time and money plus a real boost in efficiency.

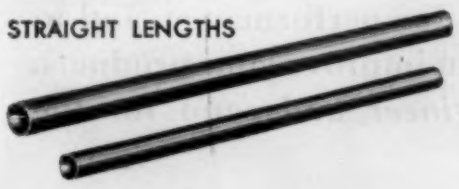
A prime example of Wolverine's fabrication ability is found in its refrigeration evaporator sub-assembly which is proving a real time-saver to busy refrigeration manufacturers. This prefabricated assembly is composed of a bunch-type aluminum coil, a one-piece accumulator (produced in one operation by Wolverine's exclusive Aluminum Spun End Process®) and two copper-to-aluminum connectors.

OTHER WOLVERINE ALUMINUM PRODUCTS

Famed for its Tubemanship, Wolverine Tube produces aluminum tube in a wide range of sizes and alloys in both drawn and extruded form. This rigidly quality controlled product is available in straight lengths, medium length coils and extra long coils.

Still another of Wolverine's varied operations is the production of extruded aluminum shapes to customer specifications.

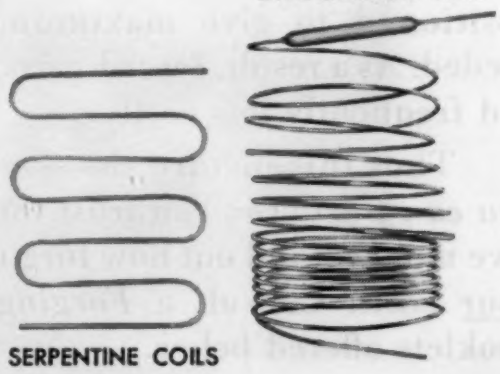
STRAIGHT LENGTHS



Also important is Wolverine's production of aluminum serpentine coils which give a maximum length of tube in small space. Other Wolverine fabrication facilities include finning, coiling, bending, flaring and expanding—to name but a few.

PROCESS PATENT APPLIED FOR

EVAPORATOR COIL



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Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

Wolverine Trufin is available in Canada through the Unifin Tube Co., London, Ontario

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This is an actual photo of a surface prepared by polishing and etching a cross-section of a forging, to reveal the "grain flow." (x2)

A PICTURE OF ADVANTAGES YOU CAN GET ONLY FROM FORGINGS

In the picture above you see the grain flow in a forging.

This picture demonstrates two things. First, the metal is dense and free from porosity. The impact or pressure of forging helps make it so. Such density is important when parts must have machined surfaces, when they must provide reliable strength and safety, and when they must be tight against leakage of liquids or gases. This quality reduces rejects and saves money. It contributes to safety and saves lives.

Second, notice how grain flow lines follow the shape of the part. This improves impact resistance and fatigue strength of the part. In closed-die forging, these flow lines can be positioned, to give maximum properties where they are needed. As a result, forged parts can be lighter, safer, stronger, and frequently less costly.

Thus this picture shows you why forged metal is *metal you can trust.* You can trust forgings for performance, and to save money. Find out how forgings can improve your products, your costs. Consult a *Forging Engineer*, and send for the booklets offered below.

closed-die **forgings** for metal you can trust

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joined by a plastics strip that is snapped over a rolled metal section that runs from roof rail to roof rail like conventional headlining bows. This type of assembly increases head room approximately ¾ in. and also possesses the advantages of vinyl. If the Masonite is perforated, proper sound insulation can be achieved.

Elastomeric floor coverings

The selection of rubber for car floor coverings has been based on rubber's inherent durability, conformability, flexibility and insulation properties. The basic rubber compound used in auto floor coverings is made to meet SAE classification R-705, which calls for 70 Shore durometer hardness, 500 psi tensile strength and 150% minimum elongation. According to J. F. McWhorter of Ohio Rubber Co., the recent addition of long wearing, colorful and easily cleaned elastomeric coatings for rubber provide a material that economically meets design competition.

Colorful coatings may be made from a wide selection of elastomers in which colored pigments have been dispersed. Most widely used elastomers for color coatings range in toughness between high modulus vinyl and low modulus butadiene-styrene copolymers. Vinyl coatings are harder and provide much greater wear resistance per unit of thickness than the butadiene-styrene coatings.

Several types of color coatings now being used in commercial production are:

Calendered — Synthetic rubber coatings such as butadiene-styrene copolymers can be joined to the rubber without cement by applying them hot on the calender. Because these are generally low modulus materials, they are calendered to a minimum thickness of 0.012 in. to provide required wear properties.

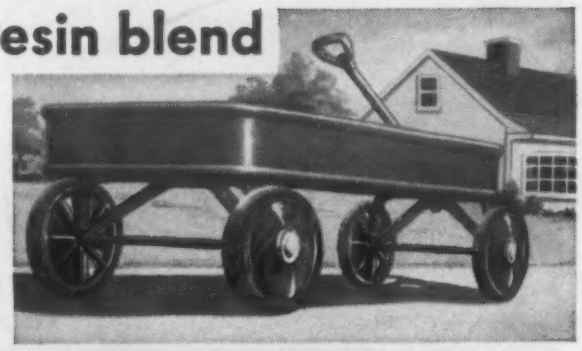
Sprayed — Water-suspended vinyl dispersion coatings can be automatically sprayed on rubber. Coated parts are then conveyed

◀ For more information, Circle No. 460

Look for

wheels that are practically wear-proof!

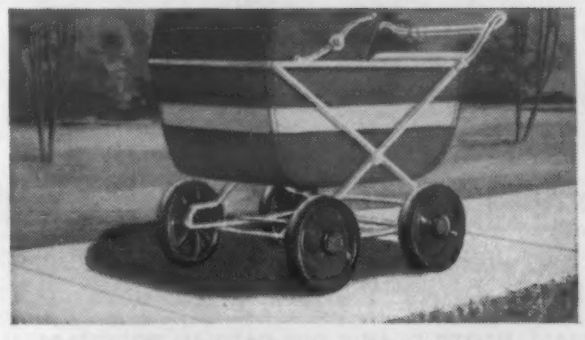
Made of KRALASTIC a rubber-resin blend



Kralastic rubber-resin—proved so outstanding in water meter covers, underground pipe, and in hundreds of other *tough* applications—now gives *wheels* wonderful new *selling* properties!

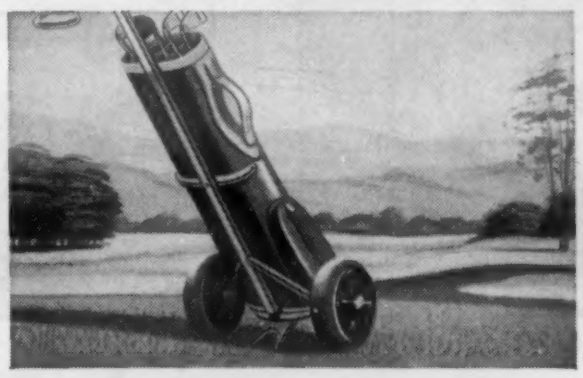
A leading lawn-mower wheel manufacturer found Kralastic wheels *far* superior to conventional steel or aluminum wheels. And dozens of end product manufacturers are already beginning to incorporate them in *their* products.

Look at the advantages Kralastic wheels offer and you'll see why!



- **lighter than aluminum!**
- **smooth, quiet running—never need oil!**
- **can't rust, rot, or corrode!**
- **will bounce ten feet high from concrete—unharmed!**
- **abrasion resistant!**
- **non-warping, resistant to weather and most chemicals!**
- **thoroughly, permanently colored!**
- **quickly injection molded—relatively inexpensive!**

Look for Kralastic in the products *you* buy and sell—in wheels, drawer slides, pulleys—wherever toughness and lack of friction are important. *Feature the advantages Kralastic offers.* It will help you sell the *complete product.*



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through ovens to evaporate the water and cure the vinyl. Coatings are approximately 0.003 in. thick.

Film—Vinyl films calendered to approximately 0.004 in. in thickness can be used to coat rubber floor coverings. An elastomeric cement is used to adhere the film to the rubber. Films must be perforated to prevent blistering during cure of the cement.

Solid vinyls have been used to make experimental floor coverings. Service test results indicate that the thickness of such coverings should be approximately equal to that of the coated rubber material. Thinner vinyl coverings have undesirable drape, loss in sharpness of surface design and poor resistance to cigarette burns. The materials cost of solid colored vinyl is many times that of the SAE-705 black rubber compound.

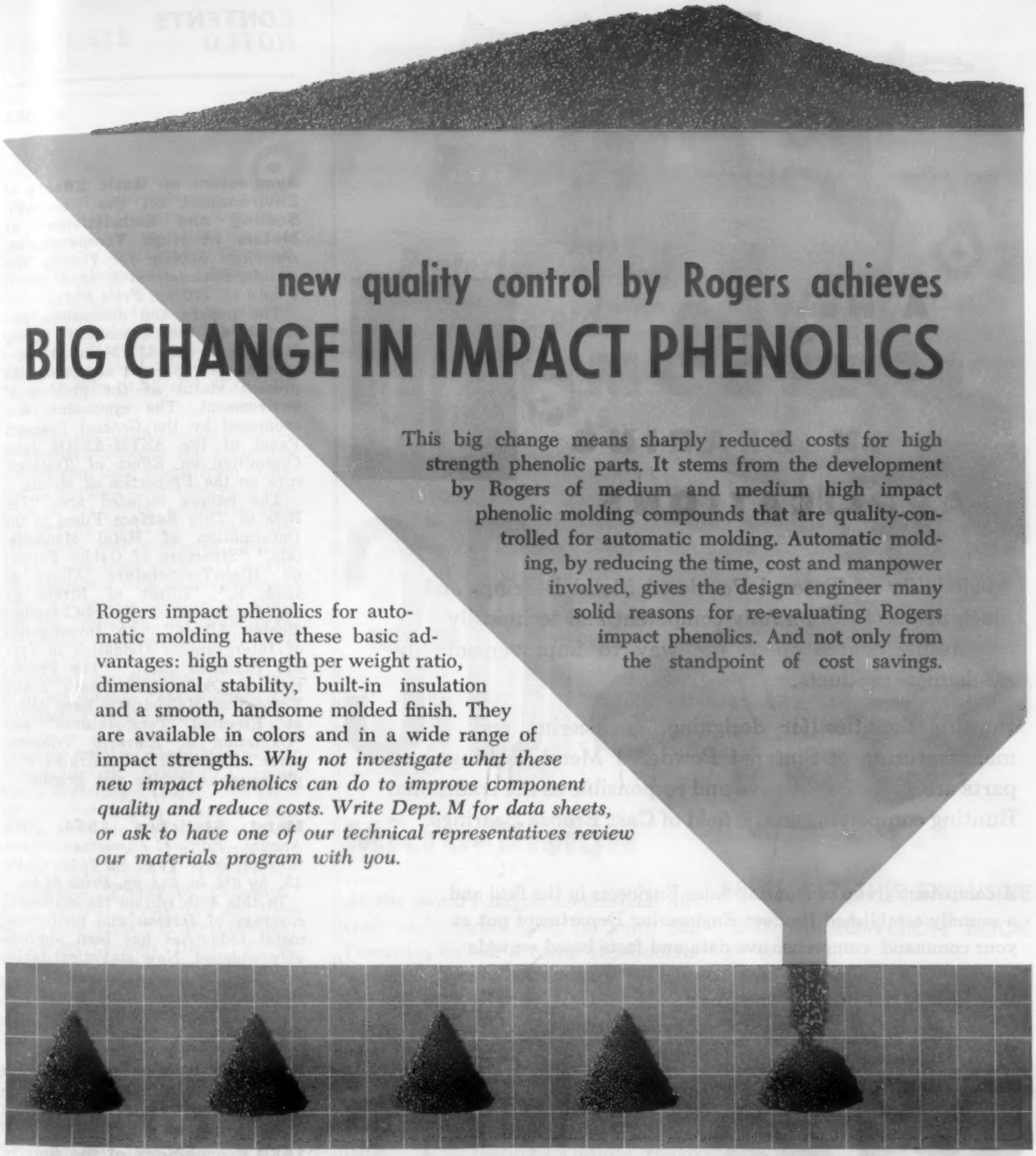
Longer Fatigue Life for Soft Solders

Cyclic loading in the range 0 to 20 psi at 255 F indicates a definite superiority in fatigue life for high tin solders over high lead grades. Reporting on the subject at a recent ASTM meeting, H. E. Pattee and R. M. Evans of Battelle Memorial Institute discussed also the effect of additions of other elements on the life of these solders.

Zinc, bismuth and antimony improve the elevated temperature properties of tin-lead solders when present in small concentrations, but are detrimental at higher concentrations. Replacement of two parts tin with one part lead and one part antimony increased the strength of 30 tin —70% lead solder but has the opposite effect in 70 tin —30% lead solder.

Under elevated temperature cyclic loading, additions of nickel, manganese, chromium, germanium, tellurium and cerium have a beneficial effect on the 70 tin —30% lead grade.

(Books on p 228)



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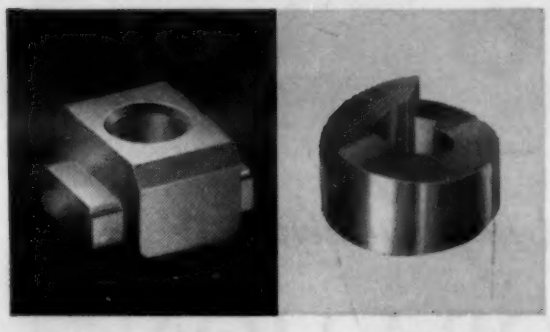

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CONTENTS NOTED

BOOKS

Symposium on Basic Effects of Environment on the Strength, Scaling and Embrittlemen of Metals at High Temperatures. *American Society for Testing Materials, Philadelphia 3. 1955. Paper, 6 by 9 in. 120 pp. Price $2.75.*

The papers and discussions presented at the Cincinnati Spring Meeting of the ASTM in 1955 are believed to represent accurately the present status of the problem of environment. The symposium was sponsored by the General Research Panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals.

The papers included are: "The Role of Thin Surface Films in the Deformation of Metal Monocrystals," "Structure of Oxides Formed on High-Temperature Alloys at 1500 F," "Effect of Strain on the Oxidation of Nickel-Chromium Heater Alloys," "An Investigation of Intergranular Oxidation in Type 310 Stainless Steel," "The Properties of Oxidation-Resistant Scales Formed on Molybdenum-Base Alloys at Elevated Temperatures" and "Oxidation at Elevated Temperatures." The book is illustrated with photographs, tables and graphs.

Metal Statistics 1956. 49th Annual Edition. *American Metal Market, New York 38. 1956. Cloth, 4¼ by 6¼ in. 844 pp. Price $3.50.*

In this 49th edition the statistical coverage of ferrous and nonferrous metal industries has been appreciably widened. New statistical tables are: titanium ingot and mill product shipments; world mine production of nickel; refiners' buying prices for copper scrap; consumption of solder in the U.S.; use of tin and lead in solder; consumption of manganese ore; and consumption of alloying metals in steelmaking.

1955 Proceedings of the American Society for Testing Materials. Volume 55. *American Society for Testing Materials, Philadelphia 3. 1956. Cloth, 6¼ by 9¼ in. 1250 pp. Price $12.*

This annual volume contains reports and papers contributed to the Society during 1955. More than 35 technical papers are listed, including the Gillett Memorial Lecture on powder metallurgy by Fritz V. Lenel. Five of the papers are on elevated temperature properties of steels, cermets and Inconel, and 12 concern fatigue investigations of steels and nonferrous metals.

(Reports on p 231)

For more information, Circle No. 590

REPORTS

Protecting molybdenum alloys PROPERTIES OF OXIDATION RESISTANT SCALES FORMED ON MOLYBDENUM-BASE ALLOYS AT ELEVATED TEMPERATURES. *M. Gleiser, W. L. Larsen, R. Speiser and J. W. Spretnak, Ohio State Univ. Feb 1955. 49 pp, graphs, tables. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D. C. Film $3.30, stat $7.80 (PB 119850)*

Due to the limitations of externally applied claddings for protecting molybdenum base alloys from oxidation at elevated temperatures, a program of developing protective, self-regenerative scales on molybdenum-base alloys was conducted. Results of oxidation tests show: 1) molybdate scales will form on molybdenum-nickel and molybdenum-cobalt alloys and are protective; 2) both nickel and cobalt molybdates spall upon thermal cycling; 3) spalling can be suppressed by addition of certain third components that stabilize the molybdate crystal structure.

Ceramic cutting tools MINUTES OF SYMPOSIUM ON CERAMIC CUTTING TOOLS. *Watertown Arsenal. Feb 1955. 127 pp, photos, dwgs, diags, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. $3.25 (PB 111757)*

Contents: "Processing Ceramics," F. H. Norton; "Properties and Uses of Ceramic Tools," E. Ryshkewitch; "Notes on Ceramic Tools," W. M. Wheildon; "Molybdenum Boride Cutting Tool," E. DiCesare; "Preparing Ceramic Tool Material," B. Bovarnick; "Machining Studies," by W. B. Kennedy.

Piezoelectric titanates PIEZOELECTRIC TITANATE CERAMICS WITH LOW TEMPERATURE COEFFICIENTS. *Don A. Berlincourt, Brush Laboratories Co. Nov 1954. 36 pp, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. $1 (PB 111812)*

Properties of barium titanate compositions containing substantial amounts of calcium titanate. These compositions have improved temperature dependence of resonant frequency, electromechanical coupling and dielectric constant, as well as higher mechanical Q.

Notch ductility of irons NOTCH DUCTILITY OF AUSTENITIC NODULAR IRONS. *R. E. Morey and H. F. Bishop, Naval Research Laboratory. Mar. 1956. 24 pp, photos, tables. Available from Office of Technical Services,*

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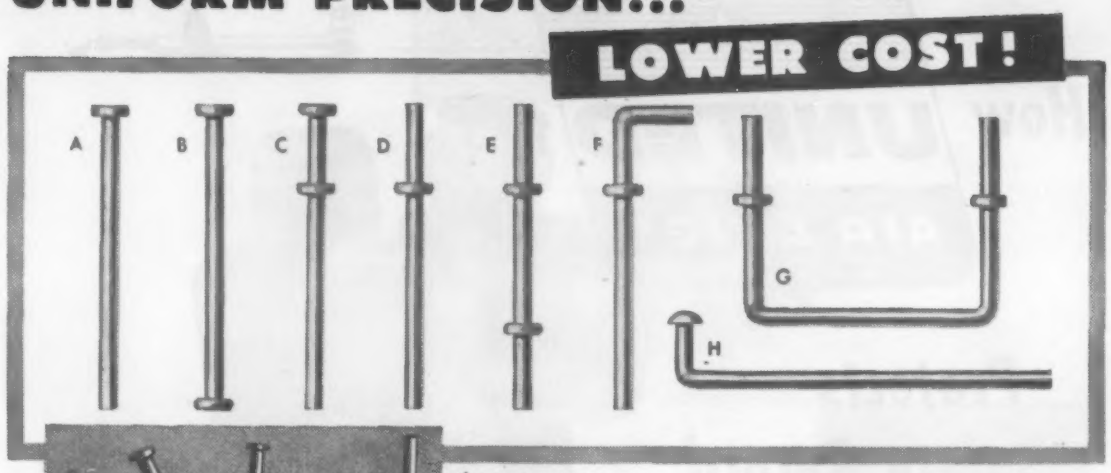

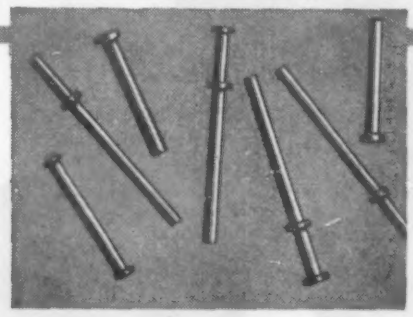

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CONTENTS NOTED

REPORTS

Dept. of Commerce, Wash. 25, D. C. 75¢ (PB 121014)

Two types were investigated by means of the drop weight test. Irons containing less than 0.6% chromium (Class B) have extremely low nil ductility transition temperatures and are recommended for low temperature applications involving severe service conditions. Irons with 1.6 to 2.25% chromium (Class A) have erratic notch ductility.

NOTCH DUCTILITY OF COMMERCIAL MALLEABLE IRONS. *H. F. Bishop, G. A. Sandoz, N. C. Howells and W. S. Pellini, Naval Research Laboratory. Mar 1956. 26 pp, photos, diag, graph, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. 75¢ (PB 111999)*

Drop weight explosion crack-starter and Charpy V-notch tests were used to establish: 1) nil ductility transition temperature, 2) relative level of resistance to fracture initiation and propagation at temperatures above the nil ductility transition, and 3) general significance of the low level transition curves in irons having ultra-sharp notches.

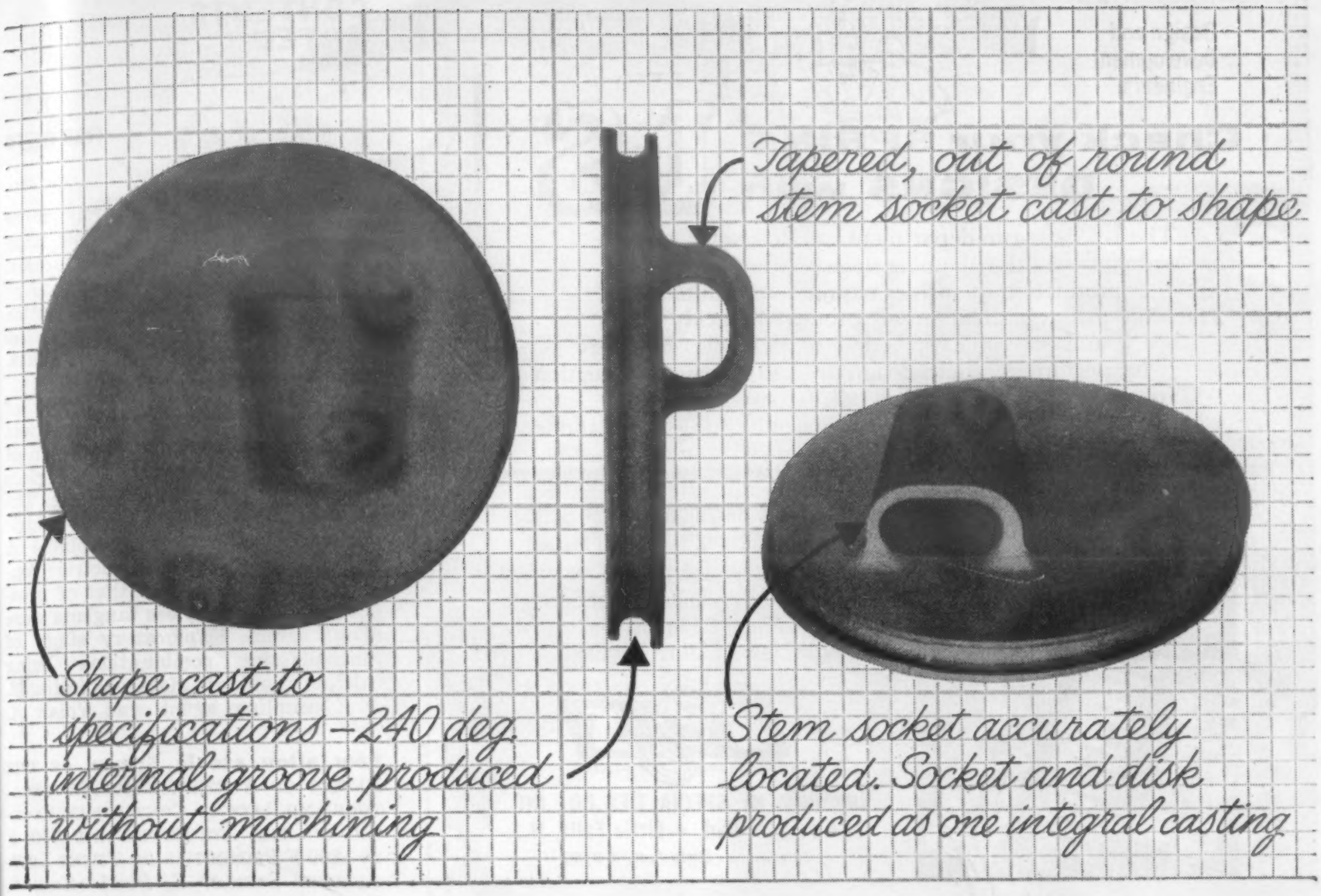
Printed circuit adhesives ADHESIVE FOR COMPOSITE MATERIALS USED IN PRINTED CIRCUITRY. *R. M. Houghton and V. G. Lorenzini, Houghton Laboratories, Inc. Mar 1955. 41 pp, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. $1.25 (PB 111869)*

Final report for period, Mar 15, 1953 through Mar 14, 1955. All studies were primarily on improving bonding of copper foil to different base laminates.

Treated magnesium surfaces RESEARCH ON TREATED MAGNESIUM SURFACES. *S. E. Rohowetz, Bjorksten Research Laboratories, Inc. July 1955. 187 pp, photos, diags, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $4.75 (PB 121140)*

Corrosion resistance tests included pH increase in 1N KCl, open circuit potential comparisons, short circuit current comparisons and hydrogen evolution rates in 1N KCl (gasometric method), the last being most promising. Tests of adhesion of zinc chromate primer to treated surfaces included shear, tension, and impact, ultrasonic vibratory and pressure-sensitive type tests (qualitative).

(more Reports on p 234)


Tapered, out of round stem socket cast to shape
Shape cast to specifications – 240 deg. internal groove produced without machining
Stem socket accurately located. Socket and disk produced as one integral casting

Investment-Cast in One Piece . . .

5 Secondary Operations Avoided

This intricate valve disk and stem socket were investment cast at a considerable saving in machining, assembling, and joining costs. The disk is produced in an odd shape and has a concave rim with a 240-degree groove. There is a tapered, out-of-round recess in the stem socket. The disk and socket were designed and produced as one integral casting.

The shape of the disk, vital to the proper functioning of the part, was cast to size. A contour machining operation would have been required to produce this shape by other methods. The groove in the rim of the disk, and the stem socket, were also cast to size . . . thus eliminating two more difficult machining operations.

An assembly operation, which would have required precision locating devices, was also avoided. The stem socket had to be accurately located . . . 0.225 in. from the centerline of the disk. This location was held to within plus or minus 0.005 in. on the finished part by the investment-casting method.

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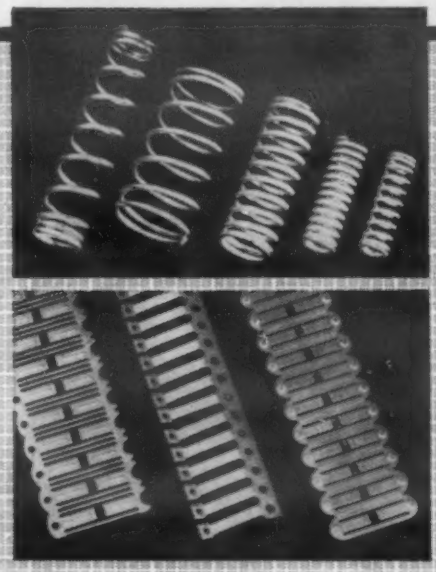

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CONTENTS NOTED

REPORTS

Fibrous glass DEVELOPMENT OF FIBROUS GLASSES HAVING HIGH ELASTIC MODULI. *G. R. Machlan, Owens-Corning Fiberglas Corp. Nov 1955. 112 pp, photos, diags, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. $3.00 (PB 111789)*

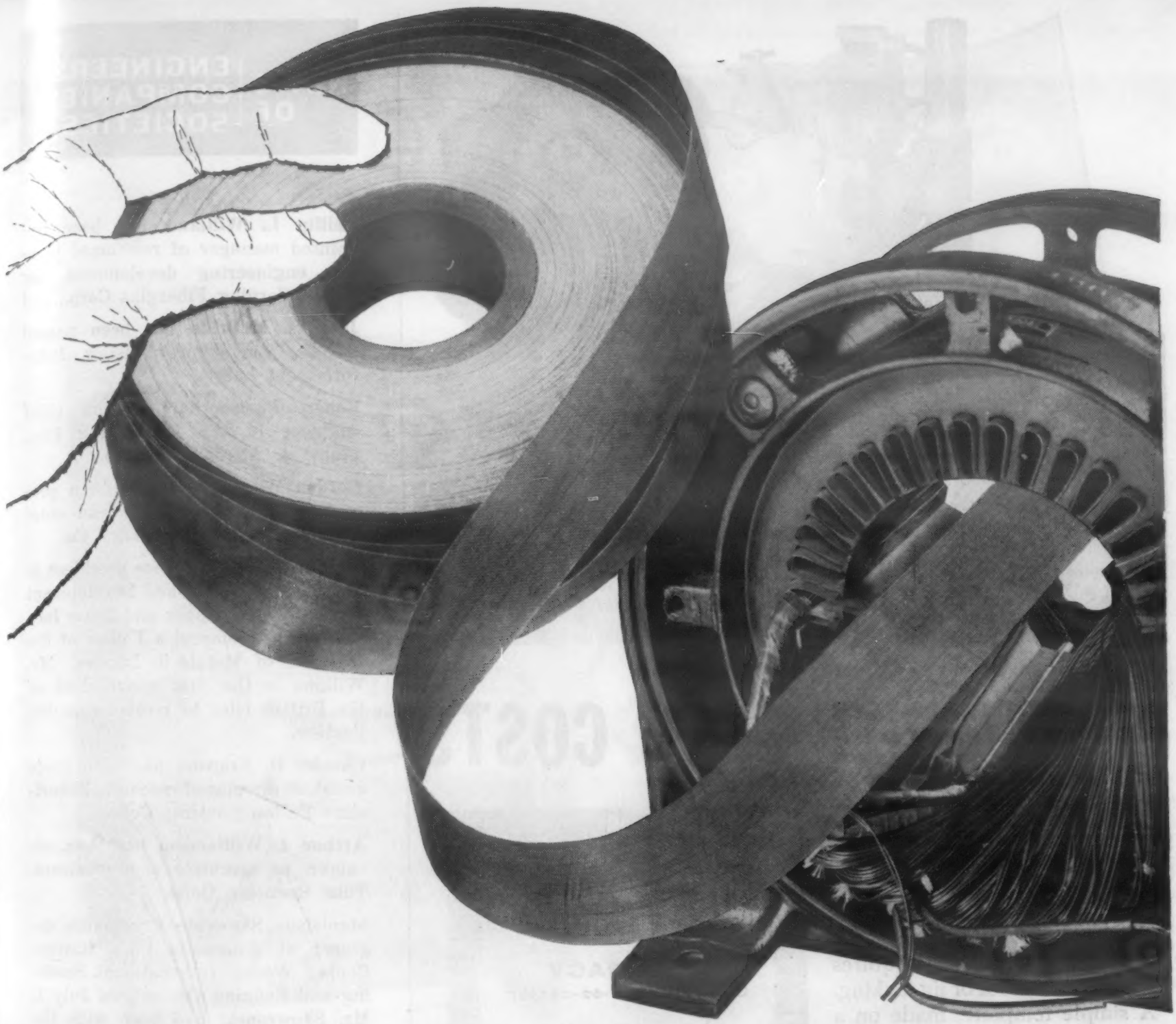
A 50% increase in modulus of elasticity of fibrous glass was achieved by continuous formation of fibers of a calcium aluminate glass in a small textile glass bushing. The glasses are resistant to hydrofluoric acid, but are completely soluble in hydrochloric acid. Dielectric constants are higher than that of present textile glass. Loss tangents were about same. Exploratory study of glass-plastics combinations using calcium aluminate glass was initiated. Best coupling agent was Volan A.

Low alloy steels SURVEY OF THE EFFECT OF AUSTENITIZING TEMPERATURE AND RATE OF CONTINUOUS COOLING ON THE STRUCTURE AND 700 F TO 1200 F PROPERTIES OF THREE LOW-ALLOYED STEELS. *K. P. MacKay, A. P. Coldren, A. I. Rush and J. W. Freeman, Univ. of Michigan, for Wright Air Development Center. Jan 1956. 77 pp, photos, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $2.00 (PB 121149)*

The three steels were Ni-Cr-Mo (SAE 4340), 1.25 Cr-Mo V ("17-22-A"S) and 3 Cr-Mo-W-V (H-40). Fully bainitic structures (predominantly upper bainite) had maximum strength, the best combinations of strength and ductility being obtained when large sections were normalized from the lower austenitizing temperatures—1750 F for SAE 4340 and "17-22-A"S, and 1950 F for H-40. All three steels increased in strength as the cooling rate after normalizing was slowed by increasing effective bar diameter from 1 to 6 in.

Chromizing titanium carbide CHROMIZING OF TITANIUM CARBIDE CERMETS. *R. L. Wachtell and R. P. Seelig, Chromalloy Corp. May 1954. 10 pp, tables. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D.C. Film $1.80, stat $1.80 (PB 120267)*

Titanium carbide cermets bonded with nickel-molybdenum or with iron-silicon can be chromized. Oxidation resistance of both compositions was markedly improved. The protective case is not disturbed by thermal cycling.



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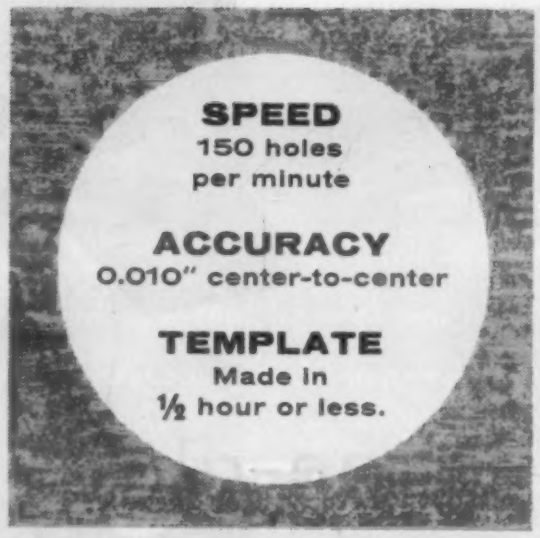

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NEWS OF ENGINEERS COMPANIES SOCIETIES

Phillip L. Williams has been appointed manager of reinforced plastics engineering development for Owens-Corning Fiberglas Corp., and

John S. McBride has been named technical manager, Plastics Reinforcement Lab.

Robert Ramsbotham is now chief engineer in the Fabricating Div., Plume & Atwood Mfg. Co.

Gordon W. Smithson has been promoted to vice president and chief engineer, Potter & Johnston Co.

Richard A. Wilkins, vice president in charge of Research and Development Dept., Revere Copper and Brass Inc., was recently elected a Fellow of the Institute of Metals in London. Mr. Wilkins is the first nonresident of the British Isles to receive this distinction.

Charles D. Branson has been made assistant director of research, Robertshaw-Fulton Controls Co.

Arthur J. Williamson has been advanced to executive vice president, Tube Reducing Corp.

Stanislaus Skowronski, research engineer at Anaconda Co.'s Raritan Copper Works, International Smelting and Refining Co., retired July 1. Mr. Skowronski had been with the Anaconda organization since 1912.

Kenith G. Strunk has been appointed administrative director of engineering, Breeze Corporations, Inc.

William Wilson has been given the newly created position of director of research and development at A. Finkl & Sons Co.

Dr. A. Eugene Schubert is now manager of General Electric's Chemical Development Dept.

Ted M. Kersker, formerly chief textile engineer for Goodyear Tire & Rubber Co., is manager of fabric development for all tire divisions of the company.

John B. Seastone has been made director of Technical Div., Olin Mathieson Chemical Corp.

William Bradford Peirce, past president of the American Society of Tool Engineers and retired vice president of research and development for Flannery Bolt Co., died July 4 at 78.

(News of Companies on p 238)

M & T CONTROLLED-ARC POWER SUPPLY

for semi- and full-automatic welding

Here's another new Metal & Thermit product — the M & T constant voltage rectifier-type DC Welder as developed originally by the Glenn Co. When used in conjunction with a constant speed wire feed for semi- and full-automatic welding, it . . .

SIMPLIFIES OPERATION — for all practical purposes it maintains a constant arc length during entire welding cycle, thereby assuring a uniform deposit.

IMPROVES WELDING—uniform deposits are of high quality, regardless of conditions which normally affect arc length such as poor fit-up, tack welds, etc. — avoids undercutting on horizontal welds.

SPEEDS PRODUCTION — instantaneous starting and recovery get job underway faster with higher average rate of deposit — practically eliminates rejects.

CUTS POWER AND INSTALLATION COSTS—high efficiency and power factor permit lower wiring and operating power costs.

M & T Controlled-Arc Power Supply units are saving time and cutting costs on many semi- and full-automatic welding operations. Write for details on how they can help you.

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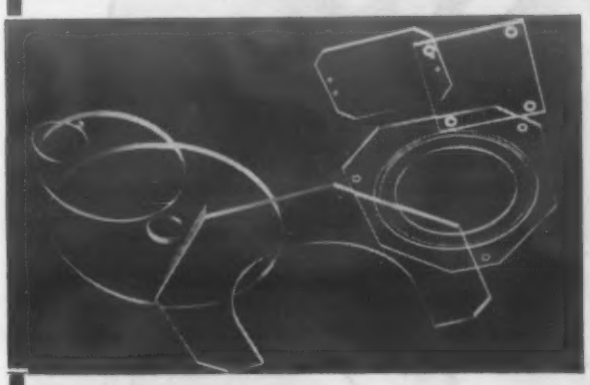

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news of | COMPANIES

Thermel, Inc., has moved into its new factory and office at 9400 Robinson Rd., Franklin Park, Ill.

U. S. Steel Corp. has announced plans to increase the ironmaking capacity of Fairless Works by 50%. A new blast furnace will be installed at the Morrisville, Pa., plant.

F. J. Stokes Machine Co. has changed its name to **F. J. Stokes Corp.**

Youngstown Manufacturing, Inc., has acquired the facilities of **Ford Moulding Co.**

Continental Can Co. has opened a new $7 million laboratory for research and engineering in Chicago.

Austenal Laboratories, Inc., has changed its name to **Austenal, Inc.**

Bohn Aluminum & Brass Corp. has purchased 30 acres of land near Butler, Ind., which will be used as the site for a new plant to produce aluminum rolled rod.

Brooks and Perkins, Inc., and **Dominion Magnesium, Ltd.,** will have joint ownership of a new high purity magnesium plant—**Alabama Metallurgical Corp.**—to be constructed in Selma, Ala. The plant is expected to be in operation in 1957.

Cutter Laboratories has completed negotiations to acquire all the outstanding common stock of Geo. A. Coleman Co., Inc., owner of **Pacific Plastic Products.**

Foote Mineral Co. has announced plans for a substantial expansion of production facilities at its Electromanganese Div. The new construction, expected to cost about $2 million, will be started immediately with completion expected in early 1958.

General Electric Co.'s Carboloy Dept. is now known as Metallurgical Products Dept.

Gomar Mfg. Co. has moved into a new, larger plant at 1501 Blancke St., Linden, N. J.

Mt. Vernon Die Casting Corp. is making extensive alterations and adding 20,000 sq ft to its plant.

National Bureau of Standards has selected 550 acres of land near Gaithersburg, Md., for relocation of the Washington laboratories. Transfer of operations to the new location is expected to be completed in about five years.

(continued on p 240)

LIKE TEST BAR— LIKE CASTING

Shown above is the new Derrick Eccentric Motor Housing made of Frontier 40-E Aluminum Alloy.*

When the Metal is FRONTIER 40-E* Aluminum Alloy!

When you purchase Frontier 40-E Aluminum Alloy Castings from a foundry licensed to produce this alloy, you are assured of the high qualities that have made this alloy famous. All licensees are required to send test bars to the technical research laboratory of the Frontier Bronze Corporation for complete analysis and physical testing. This quality control is strictly maintained.

Frontier 40-E Aluminum Alloy is noted for its high strength. It is also a well established fact that the physical properties that spell high quality in the test bar are duplicated in the product casting. And here's another feature of Frontier 40-E. High strength is obtained by natural aging at room temperatures. Heat treating is not necessary. Frontier 40-E Aluminum Alloy is of special value for parts that must be light in weight yet strong enough to resist distortion or deformation.

Yes, like the test bar, so is the casting when the metal is Frontier 40-E Aluminum Alloy . . . see table.

FRONTIER 40-E	TEST BAR	CASTING
Yield Strength	23,500	22,700
Tensile Strength	36,600	35,500
Elongation	7.5	7.5

*REG. T. M.

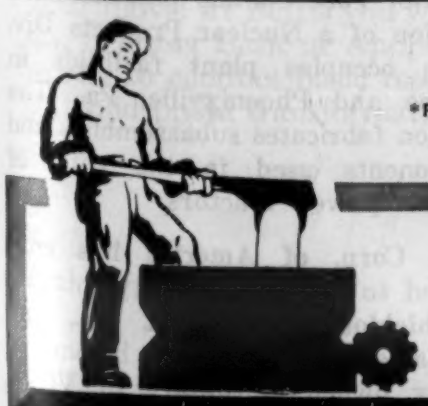
Please send me a copy of the Alloy Data Book giving Engineering and Metallurgical Facts on the physical properties of Frontier "40-E".

NAME.....

COMPANY.....

ADDRESS.....

CITY.....STATE.....



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news of | COMPANIES

Morris P. Kirk & Son, Inc., subsidiary of National Lead Co., has acquired controlling interest in **Pioneer Aluminum, Inc.** This company has been formed to consolidate and carry on the activities of Pioneer Aluminum Supply Co., Pioneer Tool Engineering Co., Consolidated Casting Co. and Republic Smelting and Refining Co.

National Lead Co.'s Doehler-Jarvis Div. has in service a new die casting plant located near Pottstown, Pa. This operation complements the other Doehler-Jarvis plant in Pottstown which has been in operation since 1924.

National Lock Co., Rockford, Ill., broke ground recently for its new $5 million fastener plant. Occupancy is expected within a year.

Permacel Tape Corp. has purchased **LePage's, Inc.** The latter firm will continue as a separate company with its own management.

Ransburg Electro-Coating Corp. has announced plans for construction of a new million dollar building to be located at 4000 W. 56th St., Indianapolis, Ind.

Rogers Corp. has announced plans for increasing the production capacity of **Cellular Rubber Products, Inc.,** which it recently purchased.

Joseph T. Ryerson & Son, Inc., has changed the name of Ryertex-Glyco Div. to Industrial Plastics and Bearings Div.

Schenectady Varnish Co., Inc., has established a new Electrical Testing and Development Laboratory at the firm's headquarters in Schenectady, N. Y.

Sharon Steel Corp. will construct a modern $6 million electric furnace shop at its Roemer Works, Farrell, Pa., which will double present capacity of the company to produce stainless and high alloy steels.

Superior Tube Co. has announced the creation of a Nuclear Products Div. which occupies plant facilities in Trappe and Phoenixville, Pa. The division fabricates subassemblies and components used in the core of nuclear power reactors.

Vitro Corp. of America has contracted to acquire majority interest in **Thieblot Aircraft Co., Inc.,** and the latter company will become a wholly owned subsidiary of Vitro.

(News of Societies on p 242)

METALLURGISTS...

Help develop the world's first nuclear powered fleet

Nuclear power offers tremendous advantage for naval vessels. From the fuel standpoint, cruising ranges are virtually unlimited—even at new high speeds. No refueling facilities will be required to replenish nuclear propulsion fuel. Therefore, the physical design of the fleet can be streamlined for greater efficiency and safety.

At the country's largest design-engineering center for nuclear power reactors, Bettis Plant in Pittsburgh, operated for the Atomic Energy Commission by Westinghouse, the application of nuclear power has progressed rapidly. However, the nuclear power plants already in operation today represent only the beginning of a new technological era. *Major advances in many areas are necessary.*

These include: the development of fuel alloys; the development of clad alloys; fuel element development; and technical control of fuel elements and fuel and clad alloys. At Bettis you will have a choice of working in either Basic or Applied Metallurgy. You may prefer to conduct basic research in areas like these: 1) Solid phase transformation, 2) Corrosion kinetics and mechanisms, 3) Effect of irradiation on metals, 4) Internal friction studies, 5) Study of equilibrium diagrams.

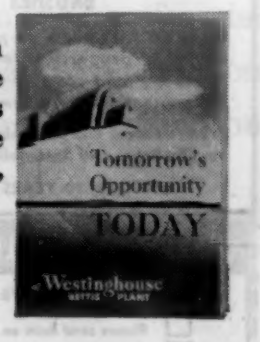
To do this, Bettis Plant needs farsighted men. Regardless of your interest, you can choose a place in the varied operations at Bettis Plant.

Atomic experience is not necessary.

What's more, Bettis Plant is in Pittsburgh's South Hills. Here you can enjoy good living in pleasant suburbs near the plant, and still be convenient to one of the nation's most progressive metropolitan areas.

Educational opportunities are exceptional. Westinghouse helps you continue your studies at any one of three Pittsburgh universities.

Write for descriptive brochure on opportunities in your field. Be sure to specify your interests. Address Mr. A. M. Johnston, Westinghouse Bettis Plant, Dept. A73, P.O. Box 1468, Pittsburgh 30 Pa.



BETTIS PLANT
Westinghouse

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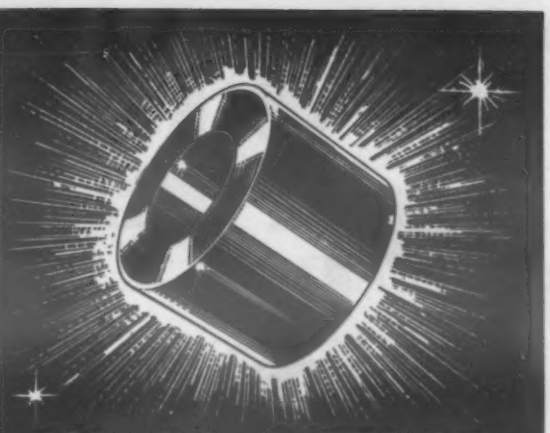

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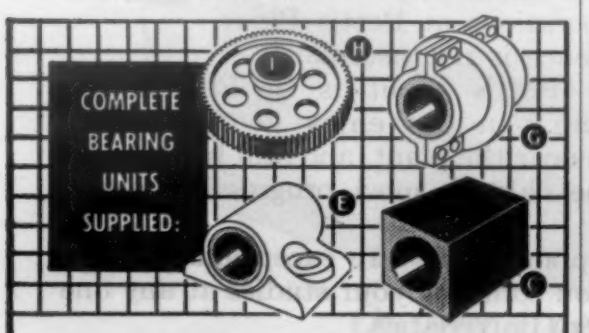
GRAPHALLOY is widely used for self-lubricating piston rings, seal rings, thrust and friction washers, pump vanes.



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news of | SOCIETIES

American Society of Mechanical Engineers has nominated William F. Ryan to serve as 1956-57 president. Mr. Ryan is vice president, director, and senior consulting engineer of Stone & Webster Engineering Corp.

Drop Forging Assn. has announced the election of new directors for three of the association's six geographical groups. Named were: Edward F. Pytka, controller, Moore Drop Forging Co.—Group I; Jack Malugen, president, J. H. Williams & Co.—Group II; Emery M. Cook, executive vice president, Transue & Williams Steel Forging Corp.—Group III.

Magnesium Assn., at its annual meeting in Colorado Springs, elected as a vice president P. B. Craighead, president of Magnesium Products of Milwaukee.

Manufacturing Chemists' Assn. has elected John L. Gillis chairman of the board. Mr. Gillis, vice president of Monsanto Chemical Co., succeeds John R. Hoover, president of B. F. Goodrich Chemical Co.

Steel Founders' Society of America has announced a third product development contest. National monetary awards totaling $6300 will be made. Closing date is June 1, 1957.

Vacuum Metallizers Assn. was recently organized by American manufacturers engaged in metal coating plastics films by vacuum processes. Milton Hammer, president, National Metallizing Corp., was elected president.

Alloy Casting Institute elected the following officers at its annual meeting in June: president—Bradley B. Evans, sales manager, Empire Steel Castings, Inc.; vice president—F. M. Fahrenwald, president, Fahralloy Co.; executive vice president and treasurer—E. A. Schoefer.

American Society of Tool Engineers has been presented a special award by Industrial Diamond Assn. of America. ASTE was given the award "in recognition of its service to the industrial diamond industry and American industry in general by its sponsorship of the Industrial Diamond Symposium in Chicago, March 19-21, 1956, and in particular for its cooperation with the management of the Industrial Diamond Assn. of America, through these many years, in the fields of technical education, exhibitions and standardization."

Let's put our heads together

Research has produced **"KARAK".** Let's put our heads together and see if we have something for you.

Pictured precision seals are illustrations of successful **"KARAK"** applications.

Carbon graphite seals—stationary or rotating—solid or sectional. Non contaminating and inert in most acids and alkalis. **KARAK** will seal water, steam, aircraft fuel, gases, grease and many less common materials.

Adaptable grades of **KARAK** meet an impressive array of physical and chemical requirements. Extreme resistance to thermal shock, withstands heat to 700°F in air, wide hardness range, transverse strength to 14000 psi are all variable properties of **KARAK.**

Would you like to know more about KARAK?

design with KARAK in mind

Ohio KARAK Carbon Co.

THE OHIO CARBON COMPANY

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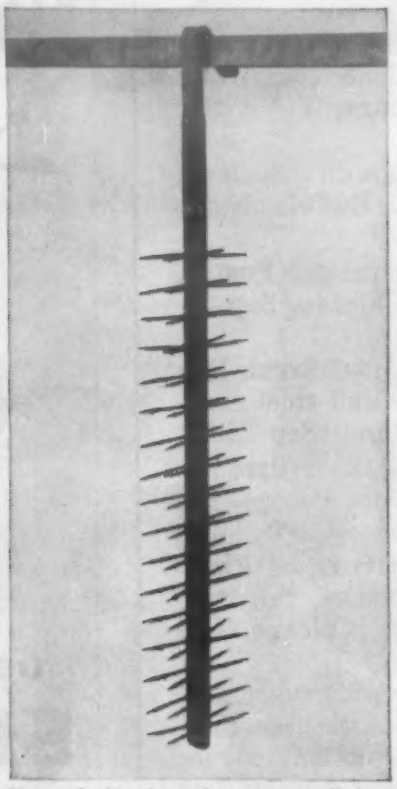
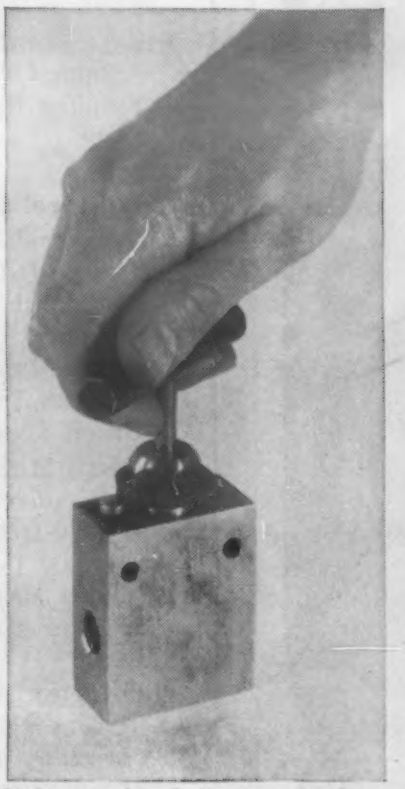
For more information, Circle No. 369

MALLORY·SHARON reports on TITANIUM

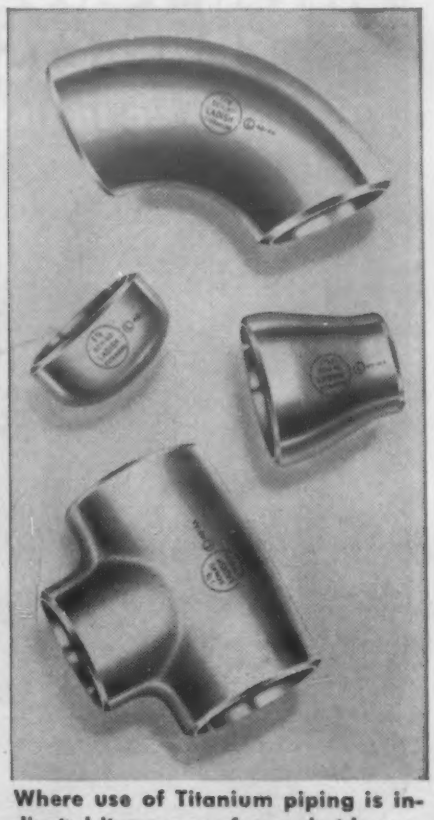
Titanium bore of steam jet ejector installed at DuPont shows no corrosion despite exposure to hydrochloric acid and high velocity steam. Previously, bore of different material had to be replaced frequently. Compare titanium bore to cast-iron flange.



Use of titanium in an anodizing rack has increased useful life from forty-five hours to one year. The sulphuric acid electrolyte used in anodizing operations quickly attacked the material previously used. Made by R. W. Renton Co.



Valve made of titanium for handling corrosive materials. Titanium is now much easier to fabricate than it was even a year ago. Thus piping, tubing, and complicated fittings are now available. Made by Autoclave Engineers, Inc.



Where use of Titanium piping is indicated, it can mean fewer shutdowns, contribute to safer operation. These Ladish Seamless Butt Welding Fittings, by Ladish Co., show versatility in fabrication of variety of fittings . . . elbow, tee, cap, and reducer.

Where **TITANIUM** *stops corrosion*

DESIGN AWAY CORROSION WITH TITANIUM

New booklet lists available data on titanium's corrosion-resistant properties, shows typical applications, and includes corrosion data charts covering behavior with many common acids and industrial chemicals. For free copy write Mallory-Sharon Titanium Corporation, Dept. G-9, Niles, Ohio.

• Titanium offers outstanding resistance to many common corrosive media, including some of the most troublesome industrial chemicals — nitric acid, moist chlorine, chlorinated organic or inorganic compounds, etc. Titanium is not susceptible to stress corrosion, and resists pitting attacks in solutions which affect other metals.

Use of this new metal can end costly shutdowns, replacements, and hazards from corroded parts. Wherever corrosion presents a tough problem, we suggest you investigate titanium. Write and tell us the nature of your corrosion problem—our service engineering group can furnish technical data, and will propose a plan for economical evaluation.

MALLORY-SHARON TITANIUM CORPORATION, NILES, OHIO

MALLORY Ti SHARON

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Gibsiloy

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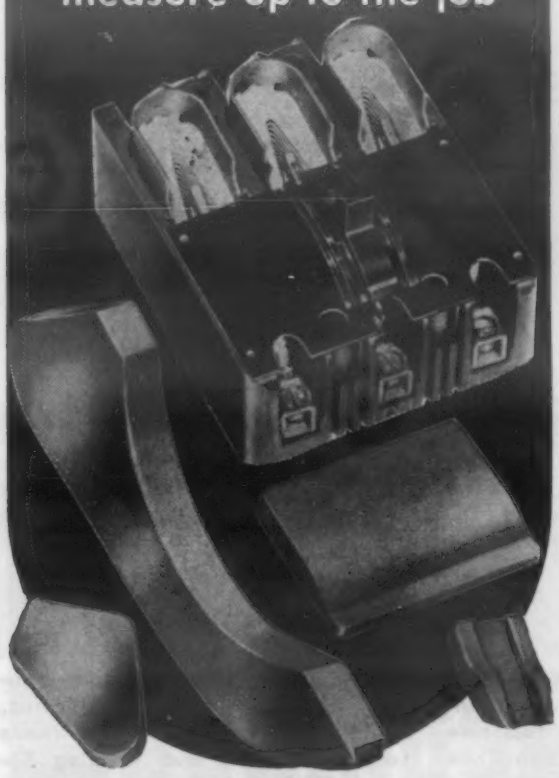
measure up to the job



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- **RIGHT PROPERTIES**
  These Gibsiloys have low contact resistance, high current-interrupting capacity, non-welding and other properties which mean trouble-free breaker operation.
- **FLEXIBILITY**
  Gibson's large range of silver-tungsten metal combinations and forms—plus our engineering skill in adapting the right contact to your product—can be a vital asset to you.
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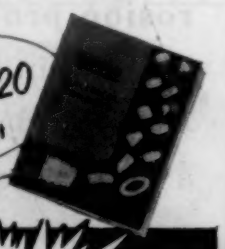
  Contacts are our business. Our round-the-clock production devoted to this one field means quick delivery of quality contacts. Let us know your needs.



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Meetings and Expositions

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, petroleum-mechanical engineering conference. Dallas, Tex. Sep 23-26.

STEEL FOUNDERS' SOCIETY OF AMERICA, fall meeting. White Sulphur Springs, W. Va. Sep 24-25.

AMERICAN ROCKET SOCIETY, fall meeting. Buffalo, N. Y. Sep 24-26.

ATOMIC INDUSTRIAL FORUM, trade fair. Chicago. Sep 24-28.

ASSN. OF IRON AND STEEL ENGINEERS, iron and steel exposition. Cleveland. Sep 25-28.

PRESSED METAL INSTITUTE, annual convention. Pocono, Pa. Sep 30-Oct 4.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall general meeting. Chicago. Oct 1-5.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting, aircraft production forum and engineering display. Los Angeles. Oct 2-6.

STANDARDS ENGINEERS SOCIETY, annual meeting. Washington, D.C. Oct 3-5.

MAGNESIUM ASSN., annual meeting. Chicago. Oct 4-5.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, Institute of Metals Div. Cleveland. Oct 8-10.

SOCIETY FOR NONDESTRUCTIVE TESTING, annual meeting. Cleveland. Oct 8-11.

NATIONAL METALS CONGRESS AND EXPOSITION, AMERICAN SOCIETY FOR METALS. Cleveland. Oct 8-12.

AMERICAN WELDING SOCIETY, national fall technical meeting. Cleveland. Oct 8-12.

SOCIETY OF THE PLASTICS INDUSTRY, New England Section conference. Portsmouth, N. H. Oct 11-12.

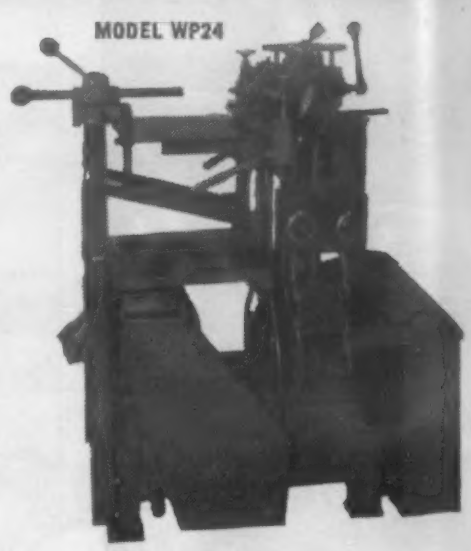
NATIONAL FOUNDRY ASSN., annual meeting. Detroit. Oct 11-12.

NATIONAL ASSN. OF CORROSION ENGINEERS, Northeast Region, symposia on protective coatings, metals and alloys, cermets and plastics and use of statistical methods. Philadelphia. Oct 15-17.

CONFERENCE ON MAGNETISM AND MAGNETIC MATERIALS, AIEE in cooperation with Amer. Physical Soc., AIME and IRE. Boston. Oct 16-18.

FOUNDRY EQUIPMENT MANUFACTURER'S ASSN., annual meeting. White Sulphur Springs, W. Va. Oct 18-20.

FOR BETTER WAX PATTERNS...



use the

SHERWOOD INJECTION PRESS

Better wax patterns will be yours every time with this modern injection press. The operation is faster and easier too!

Press is designed for production of large as well as small wax patterns. Wax is extruded under accurately controlled pressure and temperature to assure uniformity of patterns.

Removable wax cylinder holds 138 cubic inches of wax—enough to make patterns for 39 pounds of steel castings. Total wax capacity including four cylinders in reserve tank, is 690 cubic inches.

Die holding table opposite horizontal nozzle is adjustable to height. Vertical nozzle is spring-loaded for automatic discharge. Special die closing devices will be supplied to meet your specifications.

Write for Descriptive Bulletin

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For more information, Circle No. 530

It's a better feeder set ... at a lower cost.

since they switched to DYLENE* polystyrene!

Here's a feeder set designed to keep mother from graying prematurely. It has features galore! Each food section in the dish has inward-slanted sides, eliminating the need for food pushers. On the bottom of the dish is a large suction cup that keeps Junior from pushing the dish to the floor. You might say it's almost "disaster proof." The loaded-bottom cup is attached to the table by a long cord and suction cup. Inside is a special device allowing only a small flow of milk. Should the cup be dropped, only a splash or two—instead of a flood—reaches the floor.

Originally, Westland Plastics Company, Los Angeles, made this feeder set out of another type of plastic. After experimentation, Westland decided that they could make a better product, yet lower production costs, by switching to DYLENE polystyrene by Koppers. Two types of DYLENE are used in making the set. DYLENE-200 was chosen for its colorability plus impact resistance, while DYLENE-3 is used to make the tough, crystal-clear sections of the set. With the help of DYLENE, Westland Plastics has a highly marketable, attractive and practical product.

Koppers also manufactures DYLITE* expandable polystyrene, SUPER DYLAN* polyethylene and DYLAN* polyethylene, fine plastics for fine products. Full information on all of these plastics is available by writing to Koppers Company, Inc., Chemical Division, Dept. MM-96, Pittsburgh 19, Pennsylvania.

**Koppers Trademark*

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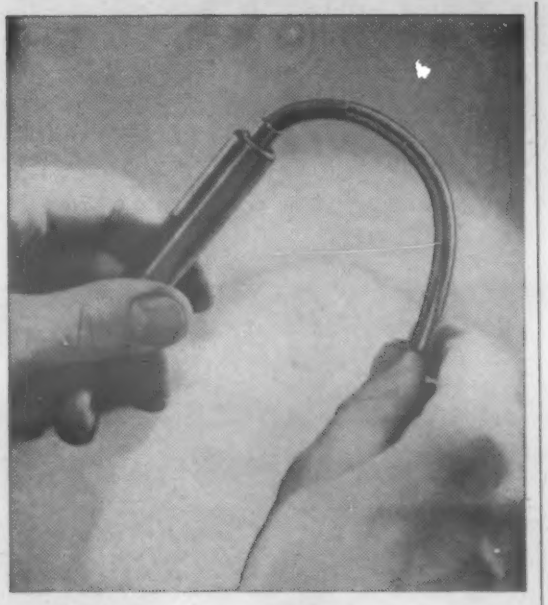

New spring stress reliever increases operating life

CHROMALOX *Electric* CARTRIDGE HEATERS

On applications which require repetitive flexing action, you can now obtain Chromalox Electric Cartridge Heaters equipped with an ingenious high tensile spring—which protects the lead wire against premature breakage.

The spring—which is mechanically locked to the cartridge heater and is not affected by heat—follows the lead wire a sufficient distance to prevent sharp twists from breaking the wire. Laboratory testing indicates that operating life of the lead wire can be increased up to 10 times with this spring stress reliever.

Chromalox Electric Cartridge Heaters equipped with the spring stress reliever are available in ⅜", ½", ⅝" and ¾" diameters.

Let the Chromalox Sales Engineering staff solve your heating problems . . . electrically.

Write for your copy of Bulletin 850

for more specific information on Chromalox Electric Cartridge Heaters.

For information on the complete line of Chromalox Electric Heaters request Catalog 50.

Edwin L. Wiegand Company

7523 Thomas Boulevard • Pittsburgh 8, Pennsylvania

EDWIN L. WIEGAND COMPANY
7523 Thomas Boulevard, Pittsburgh 8, Pa.
I would like to have—
☐ a copy of Bulletin 850
☐ a copy of Catalog 50
☐ a Sales-Engineer contact me.
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A-4457A

For more information, Circle No. 428

MATERIALS ENGINEERING NEWS

continued from p 13

***Damping properties** of low carbon steel (left) and the new Westinghouse alloy, Nivco, (right) are compared. The high damping capacity of Nivco was consciously predesigned into the alloy together with high strength and corrosion resistance.*

operate, Westinghouse engineers came up with a new superalloy to meet these specific conditions. Clarence Zener, acting director of Westinghouse research, revealed that the new alloy was deliberately designed to have high strength at temperatures as high as 1200 F with the ability to resist mechanical vibration.

Describing the way Westinghouse went about providing this specific alloy, A. W. Cochardt, advisory metallurgist at the Westinghouse laboratories, said that metallurgists had recognized that improved turbine blade materials would be required by the larger, higher temperature turbogenerator units now being developed to realize higher thermal efficiencies for the large scale generation of electricity.

Dr. Cochardt said the new alloy, Nivco, promises to be such a material. At 1200 F it has five times the strength of 12% chromium steel, and a damping capacity nearly equal to that of chromium steel at 900 F.

"The mechanical behavior of a given alloy depends, at least in part, on its magnetic properties," the Westinghouse metallurgist explained.

"After several years of research,

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Metal CLEANERS and STRIPPERS that *Have Won Approval* of 'Materials and Methods' Engineers

Are you concerned with *all* the steps taken in the preparation of a plated, painted or enameled article?

Cleaning certainly is a 'methods' step. It must rank high in your thinking because it is so important in the overall finishing picture. CLEPO Products have much to offer you in quality and effectiveness; economy, too, and what is equally important, absence of damaging stains.

Why not get acquainted with CLEPO Products? Send for our General Catalog on Cleaners, Strippers and other chemicals. If you have a problem that is bothering you now, ask to have our field service man call. Or send samples to our laboratory for study and tests.

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FREDERICK GUMM *Chemical Company Inc.*

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For more information, Circle No. 495

three products

where finish is a must...

so **CLINTON** *chose* **KUX**

DIE CASTING MACHINES

to get hardware finish quality castings

Every sales manager has told his production department at one time or another, "The product's fine, but you've got to dress it up."

At which time the production man starts talking about increased costs.

But many manufacturers have found they can "dress up" their products, and at the same time, *lower* manufacturing costs.

The Clinton Machine Company, Clinton, Michigan, did just that. "We use Kux Die Casting Machines in the manufacture of approximately 60% of the component parts of our Clinton engines, chain-saws and outboards.

"We chose Kux because our standards require machines that give us a dense, hardware quality finish with castings to close tolerances. The efficiency and low maintenance costs of Kux Machines have cut our production costs sharply, too," says R. E. Porter of Clinton Machine.

KUX produces a full range of modern die casting machines that require only the touch of an electric button to put them automatically through a complete casting cycle at high production speeds. Kux engineers will be glad to show you how die casting machines can serve you, or write for an illustrated catalog.

MODEL HP 37 ILLUSTRATED

Hydraulically operated die casting machine for production of aluminum casting weighing up to 10 pounds.

KUX MACHINE CO. 6725 NORTH RIDGE AVENUE • CHICAGO 26, ILLINOIS

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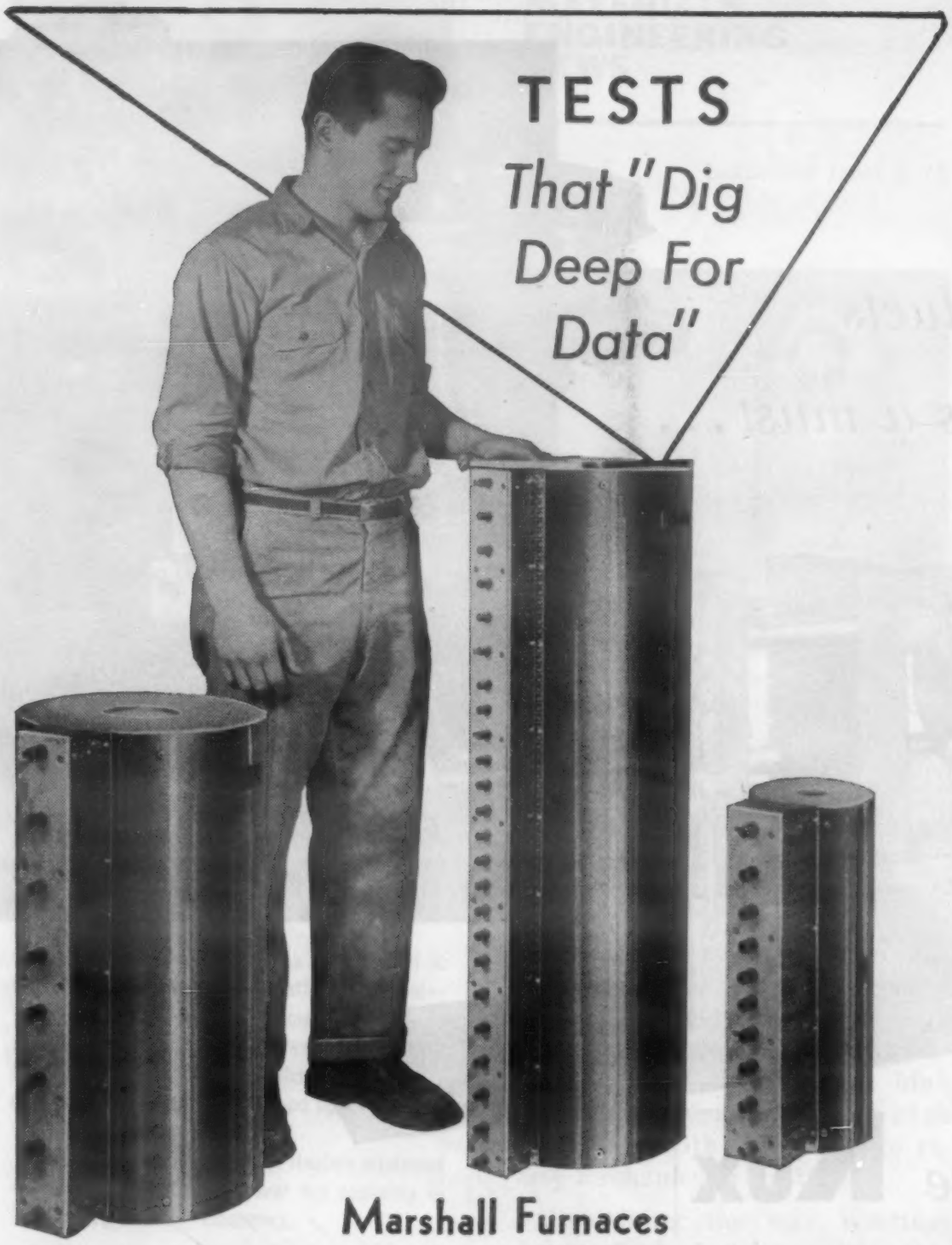


Marshall Furnaces

Are Built To "Get The Facts"

Marshall Furnaces enable the research engineer to get accurate answers to all his high-temperature test problems. This includes tests for tensile strength, creep rates, and for stress-rupture data.

It is easy temperature-control that does it! In Marshall Furnaces temperatures can be "spot" regulated or controlled zone-by-zone over the specimen, to attain most accurate test results.

Tell us your furnace problem. If your test conditions are special, we'll build Marshall Furnaces to your specifications. We can also build them in special sizes, as shown above. Write direct to Marshall Products Co., 270 W. Lane Ave., Columbus 2, Ohio.

Tensile Test type Marshall Furnace is shown at right. Brackets can be furnished for attaching furnace to test machines.

Marshall

FURNACES -- CONTROL PANELS

For more information, turn to Reader Service Card, Circle No. 482

MATERIALS ENGINEERING NEWS

we discovered how to design needed mechanical behavior into certain alloys by control of their magnetic structure. This enables us to predict the behavior we will get by combining certain metals in different proportions, and we can do this without preparing and testing hundreds of thousands of potential combinations of two or more alloying metals."

He went on to explain that the new alloy appreciably snubs vibration of the turbine blading simply because its magnetic structure dictates that it cannot vibrate. This ability was consciously predesigned into the metal.

Alloy development

Development of the high damping turbine alloy was a three stage research project:

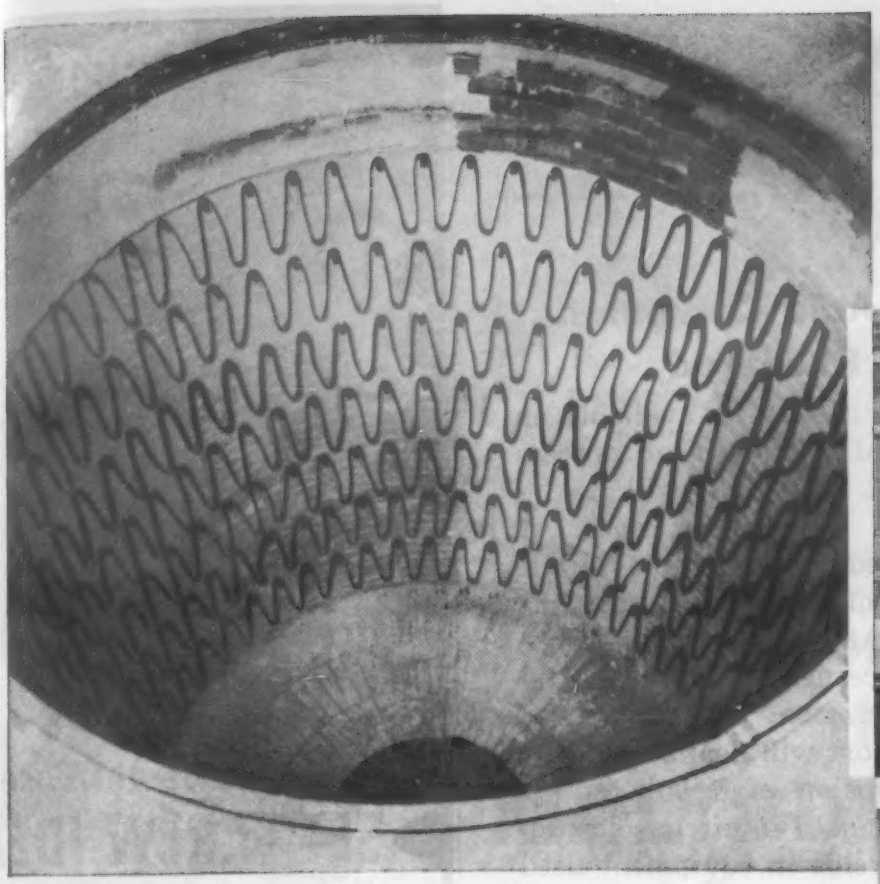
1. Initial stage consisted of a study of the magnetomechanical effects in metals, including magnetostriction, the tendency for certain metals to change dimensions under the influence of a magnetic field.

2. Basic theories gained from the initial study were tested by preparing and analyzing some 50 different alloys, studying in detail their damping, corrosion resistance, hardness, tensile strength and ductility.

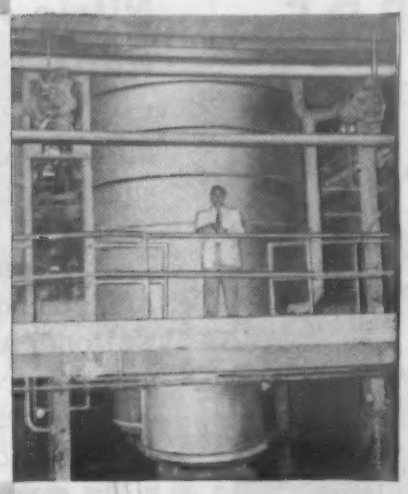
3. From the preceding data, the combination of metals which resulted in a high strength, corrosion resistant alloy with high damping properties was selected, and the result was the new alloy, Nivco.

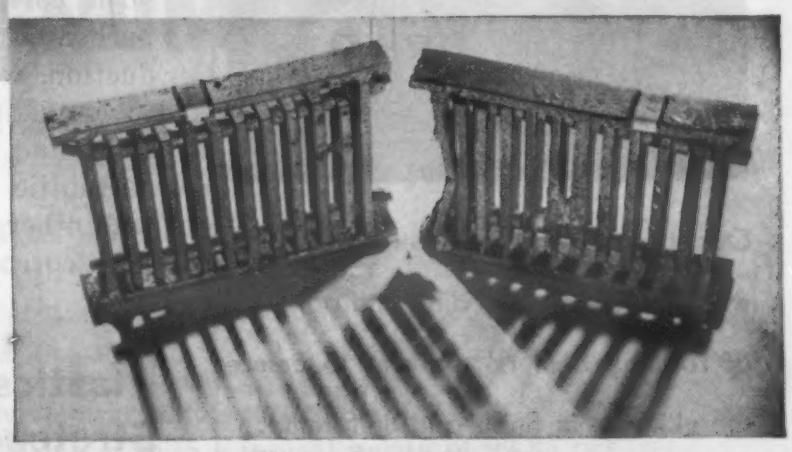
The exact composition of Nivco has not been revealed. It is composed principally of cobalt and nickel with smaller amounts of five additional elements. The ultimate tensile strength of the metal is about 100,000 psi at 1200 F. The alloy is prepared by melting in a vacuum furnace under an argon atmosphere. After melting, it is treated and forged at 2000 F

(more News on p 250)



This Vacuum Retort was used at Pacific Northwest Alloys, Inc., Spokane, Washington, for producing low carbon ferrochrome. Temperature was held at over 2175°F. for several days during production cycles. Atmosphere, primarily carbon monoxide, contained some metal vapor at an absolute pressure that varied from one inch to 100 microns of mercury. During 10 production runs, INCO Engineers tested a variety of heat-resistant alloys in this furnace.





Which Alloy Will Perform Best? Racks like these, often help to determine exactly the right metal for a specific application. Various cast and wrought alloys were assembled on the two racks, and placed in the retort, shown above, for 10 production cycles. One of the specimens under test was practically immune to corrosion with a loss of only .006 ipy. Average corrosion rates in inches penetration per year for the other specimens ranged from .015 to .153 inches.

Inco finds answers to

High-Temperature Problems

in plant tests

How often have you wanted to know which alloy will stand up best under certain high-temperature corrosive conditions?

Whether you are a user or producer of high-temperature equipment, it is now possible for you to specify metals or alloys on the basis of their behavior under actual operating environments . . . thanks to INCO's High Temperature Service.

INCO has tested scores of metals and alloys at elevated temperatures, in plant operations of all sorts. These tests have yielded information on the relative resistances to scaling and corrosion, as well as on other pertinent properties of the materials tested . . . under high temperatures in many diverse atmospheres.

We will gladly help you find answers to high-temperature difficulties in your own plant. Fill in the coupon for a high temperature work sheet . . . on which you can easily outline your problem to us.

The International Nickel Company, Inc.
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Please send me the High Temperature Work Sheet so that I may outline my problem to you.

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Quality control of Somers Thin Strip even includes the grinding and polishing of rolls by Somers' experts, to assure the ultimate in finish and uniformity.

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For more information, Circle No. 451

MATERIALS ENGINEERING NEWS

Nitric Acid Corrosion Report Prepared

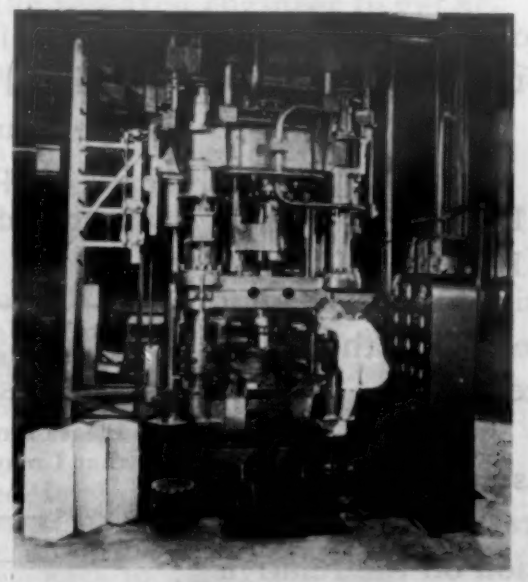
Data will soon be available on nitric acid corrosion of process equipment. The data will be included in a progress report of Task Group T-5A-5 on Nitric Acid, one of the committees of the National Assn. of Corrosion Engineers concerned with process industry corrosion.

The report will deal specifically with corrosion of reboilers, air preheaters used in nitric acid production, welds in equipment used to handle mixed solutions of sulfuric and nitric acids, ferrite in austenitic stainless steel welds and other aspects of the nitric acid corrosion problem.

Plastics Pipeline Stretches 98 Miles

A 98-mile plastics pipeline was recently installed in west Texas to carry natural gas to power irrigation pumps.

The pipe was made from Kralastic, a plastics-rubber blend produced by Naugatuck Chemical



U. S. Graphite Co.

Metal powder press The world's largest multiple-action press for sintered metal bearings and parts was recently put into operation. The 300-ton press will permit pressing of parts having a difficult "H" cross section or other unusual design.

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FREE BULLETIN
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Manufacturers are saving thousands of dollars with Setko Hopper-Fed Set Screws. Applied with special equipment* adapted to your machines. Ask us about free demonstration at our plant.

MORE THAN 30...

Special types of set screws (only a few shown here) described and illustrated in the Jewel Case Bulletin of Set Screw Ideas. Also tells how to get this handsome case, filled with actual set screws of all kinds, sent to you on loan without cost or obligation.

ZIP-GRIP† Self-Locking Set Screws
HEXAGON Socket Head Cap Screws
FLUTED SOCKET Set Screws Tamper resistant
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STANDARD Hexagon Socket Set Screws

Jot Your Name and Address in the margin of this ad, and your copy of the Free Bulletin on Jewel Case of Set Screw Ideas will be sent to you at once.

If You Want Samples —include a brief description of your set screw applications and we will send samples of actual screws to meet your needs.

† Pat. Pend.

* Pat. No. 2,638,945 other Patents Pending

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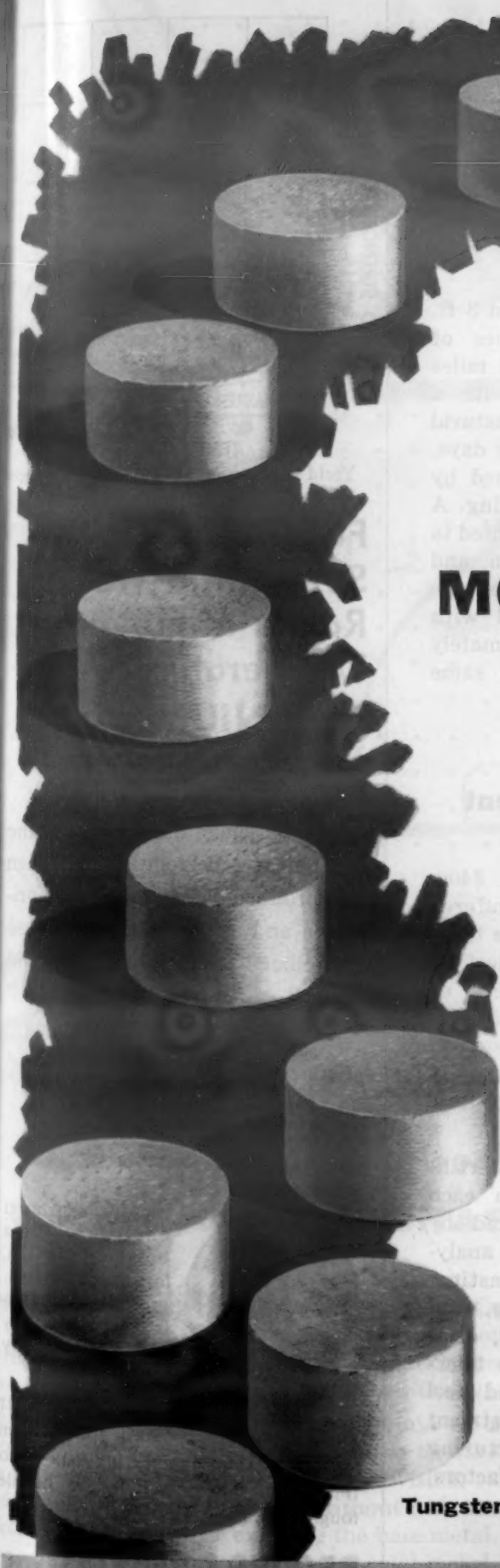

NEW
from Sylvania
High purity
MOLYBDENUM PELLETS
for vacuum melting

If you are a producer of high creep strength alloys or high-temperature super alloys, you will find that Sylvania's molybdenum pellets have the characteristics you need to meet exacting specifications.

Sylvania's molybdenum pellets are controlled to a 99.5 per cent minimum purity, with a typical purity of 99.85 per cent. Gas content is kept low by maintaining a maximum density. Pellets (1″ in diameter by ½″ thick) make it easy to calculate additions and charge to the melt.

Pelletized molybdenum offers obvious advantages over scrap in alloy production. Unit costs are constant. Reproducibility of results is assured. High purity and low gas content make it easier and less costly to meet rigid production specifications.

Also available from Sylvania is high-purity tungsten, in sintered ingot form, suitable for vacuum melt alloying.

A Sylvania sales engineer will be glad to discuss your molybdenum and tungsten needs with you. Write for technical specifications and quotations.

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Tungsten and Chemical Division
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If you are designing new products ... or are searching for a more efficient material for existing products ...consider carbon parts—machined by Speer.

Versatile and economical ... carbon products machined by Speer range from feather-light resistors to 1300-pound electrodes.

Speer carbon may help you improve product performance... reduce unit costs. Write today for full details.

Carbon Is Versatile!

Can be:	Has:
Sawed	High corrosion resistance
Drilled	High heat transfer
Milled	Low electrical resistance
Broached	High thermal shock resistance
Turned	High heat transfer (graphite)
Planed	
Hobbed	Is:
Ground	Non-warping
Molded	Non wetted by molten metals
Extruded	Chemically inert
	Self-lubricating (graphite)

SPEER Carbon Co.

St. Marys, Pennsylvania

Divisions:
Speer Resistor • Jeffers Electronics
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For more information, Circle No. 568

MATERIALS ENGINEERING NEWS

Div. of U. S. Rubber Co. It was formed into 30-ft lengths of pipe of 2-in. dia by Republic Steel Corp.

The plastics line is buried 3 ft. deep and runs in a series of branches ranging up to 15 miles long to link the pumps with a main pipe line carrying natural gas. Installed in 31 working days, the pipe lengths were joined by cementing and solvent-welding. A sleeve-type fitting was cemented to one end of the pipe section, and into it was slipped a bare pipe end that had been coated with solvent cement. In approximately 1 min, the weld had the same strength as the pipe.

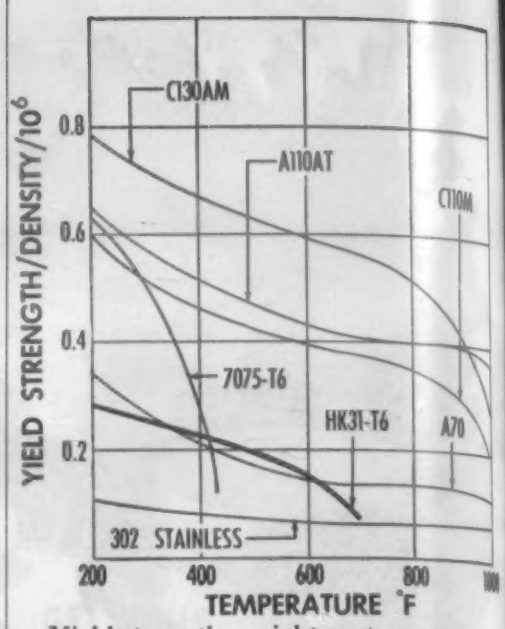
Product Development Contest Announced

Prizes of $1000, $750, $400, $200 and $100 are being offered in each of two classes in the third Product Development Contest of the Steel Founders' Society of America. Class I includes all persons not employed by the steel castings industry and Class II covers its employees. The contest closes June 1, 1957.

In addition to the prizes, certificates will be awarded in each class. The subjects covered by the contest are: functional analysis, engineering a steel casting, redesign of a steel casting, conversion to a steel casting, cast-weld, composite-weld, close tolerance steel castings, improved steel castings performance, treatment of a steel casting, manufacturing operations, administrative factors, inspection, and steel castings in use.

Awards will be announced at the annual fall meeting of the Steel Founders' Society in 1957. Information about the contest can be obtained from: Product & Market Development Committee of the S.F.S.A., 606 Terminal Tower Bldg., Cleveland 13, Ohio.

(more News on p 254)



Yield strength, weight vs. temperature.

For High Strength-to-Weight Ratios at Elevated Temperatures— TITANIUM and MAGNESIUM

The experience, the specialists, the equipment-and-facilities to design and produce the *very difficult* fabrication and assembly work in these and other light metals—you'll find at B&P.

To make this titanium pressurized tank, B&P welds two cylinders. Each is drawn in one operation. Tank withstands 5000 psi pressure.

Magnesium turret enclosure for a bomber. Design, lofting, prototypes, production fabrication and assembly are all done by B&P.

ENGINEERING FACILITIES IN DETROIT AND LOS ANGELES .. Write for Titanium and Magnesium engineering data—also folder on B&P's facilities to handle tough jobs.

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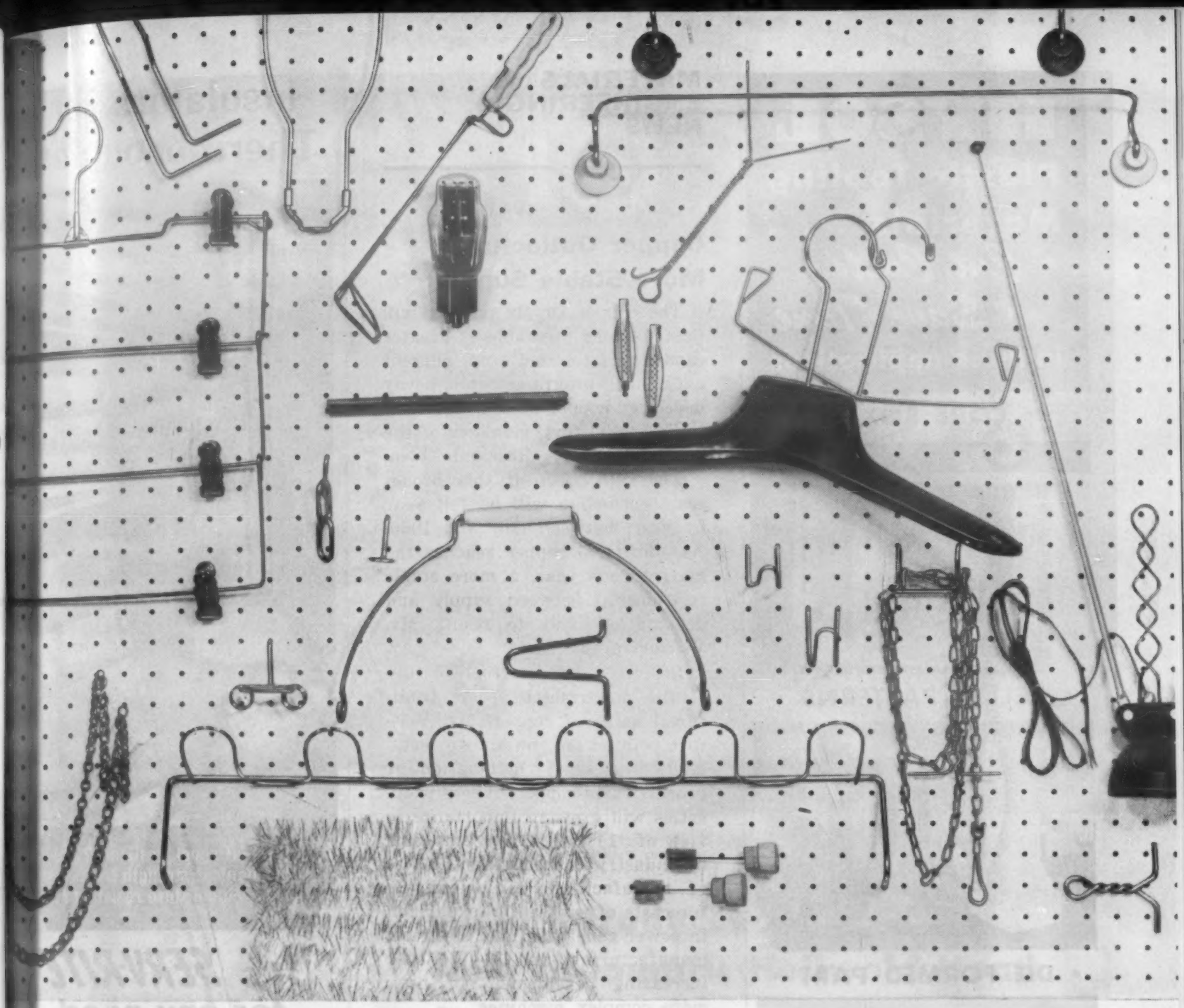

How these products were improved and costs lowered . . .

with **NICKELPLY*, BRASSPLY*** and **COPPERPLY*** wire!

• National-Standard Nickelply, Brassply and Copperply is electro-jacketed steel wire—a new development offering important advantages to manufacturers and users of wire forms and components. Specifically . . . . .

The jacket metal, precisely concentric and to the required thickness, *is inseparably bonded to the steel wire.* The materials can be severely formed, twisted, swaged, welded, roll threaded or redrawn without fracturing the jacket metal or otherwise exposing the base metal. Thus these new materials can often replace solid nickel, brass or copper wire, or can eliminate the costly post-plating of steel wire forms . . . and with unmatched assurance of coating coverage! Advantages in strength, durability and economy are obvious.

Nickelply, Brassply and Copperply are now available commercially in diameters up to .340". Pertinent data on coating weights, strengths, finishes, base materials, corrosion resistance, etc., are given in Bulletin K-10. Why not send for it now and explore these new possibilities?

*Trade Mark National-Standard Company

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Tire Wire, Stainless, Fabricated Braids and Tape

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Flat, High Carbon, Cold Rolled Spring Steel

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WAGNER LITHO MACHINERY DIVISION • JERSEY CITY, N. J.
Special Machinery for Metal Decorating

WORCESTER WIRE WORKS DIVISION • WORCESTER, MASS.
Round and Shaped Steel Wire, Small Sizes

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Plastic Tooling Materials . . .

• *Cut Costs*

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in these applications

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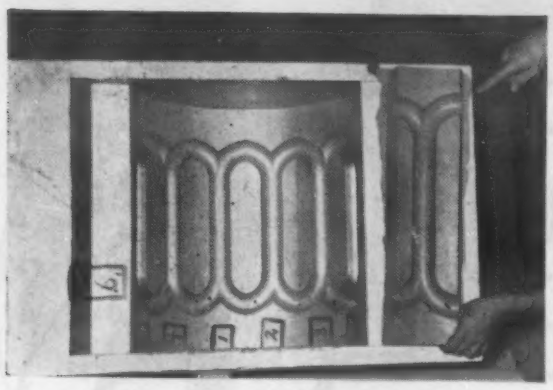
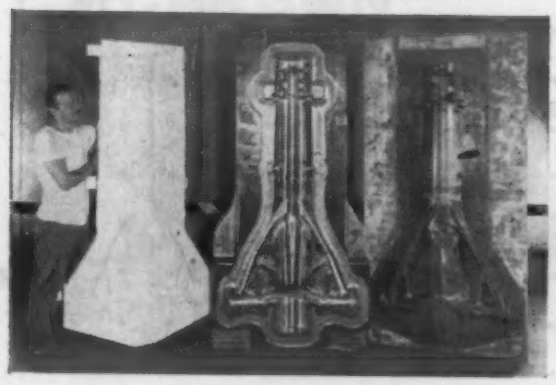


• KELLER PATTERNS •



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For more information, Circle No. 504

MATERIALS ENGINEERING NEWS

Copper Outlook: More Stable Supply

The copper supply pattern will become more favorable as greater capacity is realized from current expansion programs and newly developed copper mines, according to T. E. Veltfort, manager of the Copper & Brass Research Assn.

The full effect of this broad-scale expansion will be felt year by year, between now and 1960. As additional copper reaches the market each year, a more stable relationship between supply and demand is likely to result, Mr. Veltfort predicted.

Despite a definite trend to substitute materials by some traditional users of copper, Mr. Veltfort pointed out, no known metal offers the same combination of properties as copper. These properties will grow in importance in view of: 1) the current emphasis by industry on reducing the size of manufactured equipment, 2) forecasts of substantial expansion in power generation and electrical manufacturing, and 3) the ever increasing development of new, more complex machines.

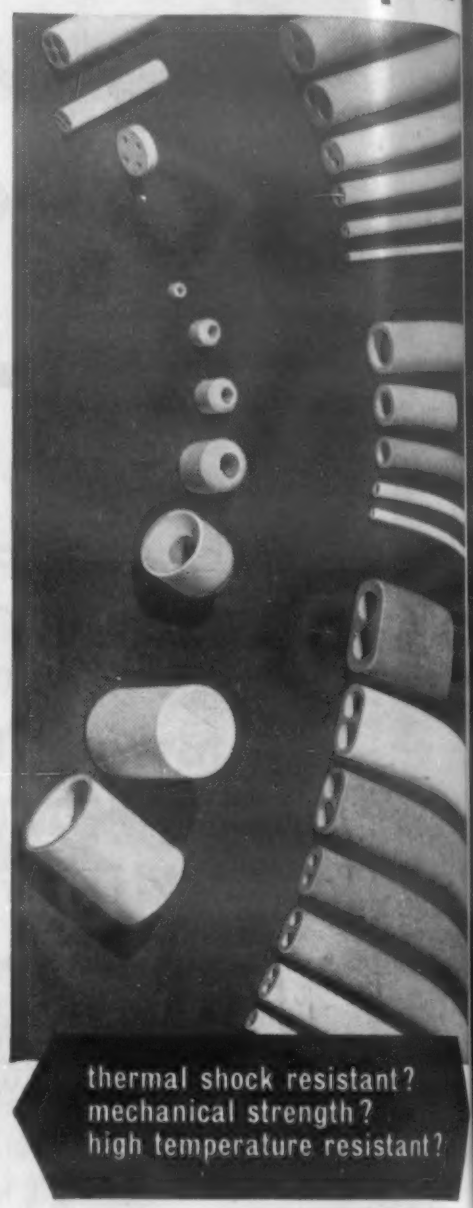
Source of Cobalt Data Established at Battelle

A Cobalt Information Center has been established at Battelle Memorial Institute, Columbus, Ohio. Its purpose is to encourage cobalt research and to provide technical and economic information for users in the metallurgical, chemical, ceramics, electronics, and nucleonics industries.

Supported by major cobalt producers, the center will gather and organize data on technological advances. This information will then be disseminated to persons and industries desiring information on cobalt. Address of the information center is 505 King Ave., Columbus 1, Ohio.

(more News on p 256)

Insulators for Thermocouples



thermal shock resistant?
mechanical strength?
high temperature resistant?

It's SERV-RITE for any need

One or more of these SERV-RITE thermocouple insulators will take care of your needs. If not, there are many more in Gordon's large stock for quick delivery. If you need something entirely special, it can be made to suit your specific requirements.

In the 50 years that Gordon has been supplying thermocouples and accessories to industry, emphasis has been on uniform top quality, service, and value. And so with insulators for any thermocouple application, SERV-RITE assures you of plus values every time.

Write for full information on SERV-RITE thermocouple insulators.

Ask for Bulletin 300-56

This new 4-page bulletin gives specifications and ordering data on all Gordon standard SERV-RITE thermocouple insulators grouped for easy selection.

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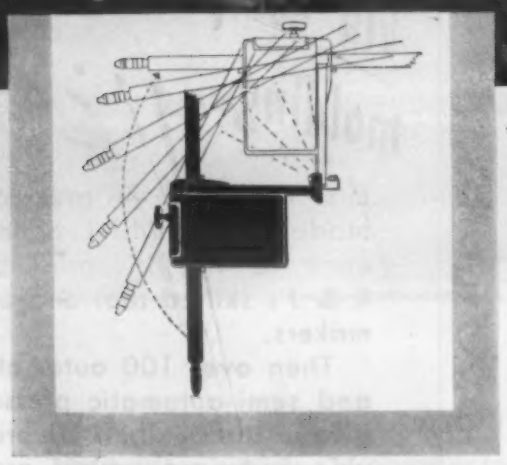

New Airco Model C Heliweld automatic head operates at all angles from horizontal to vertical.

Airco introduces New Automatic Heliweld Head for long-run production welding

The Model C Heliweld automatic head is specifically designed for long-run production on regular or irregular contours – aluminum tubing, motor stators, irregularly-shaped pressure vessels. Its prime advantage is that once the required arc length is set the head will automatically maintain this distance by moving the holder up or down to follow the contours of the work piece. Other benefits are:

- **Versatility** – unit provides good arc voltage control using either argon or helium shielding gases or mixture of both.
- **Adaptability** –the head can be operated at all angles from the horizontal to the vertical (normal) position. The maximum raise-lower distance of the electrode holder is a full 16".
- **Flexibility** – the assembly can be used for AC or DC welding, with or without filler wire. Electrode diameters range from .020 to ⅛".

The use of the new automatic head will be required where welds of consistent dimensions and quality are important and where good weld appearance is necessary or where welding specifications are very high for the electrical, aircraft, and refrigeration industries. Complete information covering the wide range of applications and detailed specification data is available. Write Airco at the first opportunity.

AT THE FRONTIERS OF welding PROGRESS YOU'LL FIND . . . AN AIR REDUCTION PRODUCT

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• For more information, turn to Reader Service Card, Circle No. 491

CASE HISTORIES
Die Casting Houses Radio Antenna Drive *
To ELIMINATE a multiple-piece assembly, a one-piece zinc die casting was selected for the housing of an electrically-driven radio antenna, shown. Use of zinc for the housing also provides improved corrosion resistance without finishing, and reduces machining and assembly operations. Manufactured by the Pioneer Specialty Company, Detroit, the unit is currently being used on the 1956 Cadillac.
The housing is designed to hold all the

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BY PARAMOUNT

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1. **Eliminated a multi-piece assembly.**
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*PARTIAL REPRINT—
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April, 1956

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Paramount
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For more information, Circle No. 475

MATERIALS ENGINEERING NEWS

New Company Formed to Produce Magnesium

With the formation of the Alabama Metallurgical Corp. to produce magnesium by the ferrosilicon reduction process, the United States will have two sources of magnesium supply within its borders. Dow Chemical Co. is currently the sole supplier of commercial magnesium in this country.

Unlike Dow, which reduces magnesium chloride obtained from sea water, the new company will reduce magnesium oxide obtained from dolomite rock by means of the ferrosilicon process. Dominion Magnesium, Ltd. of Canada operates a ferrosilicon reduction plant of this kind at the present time. Alabama Metallurgical Corp. will be jointly owned by the Canadian company and Brooks & Perkins, Inc.

The new plant will be located on a 480-acre tract 50 miles west of Montgomery, Ala. It is scheduled to go into operation in 1957.

Research Breakdown: 30 Basic, 70% Applied

Latest available figures compiled by the National Science Foundation show that 543 cooperative groups—trade organizations, professional and technical societies, agricultural cooperatives, and research-educational cooperatives—spent $21 million for research and development in 1953.

Except for a small amount spent for social science research, practically the full amount was spent for technical research and development. Approximately 70% was spent for applied research and 30% for basic research, the latter mainly in the chemical and engineering sciences.

Expenditures by individual organizations ranged from less than $100 to nearly $1.7 million. Of

Let K & J bring these designs to life via compression molding . . . . .

First the mold — precision made with faithful adherence to the blueprint by K & J's skilled tool and die makers.

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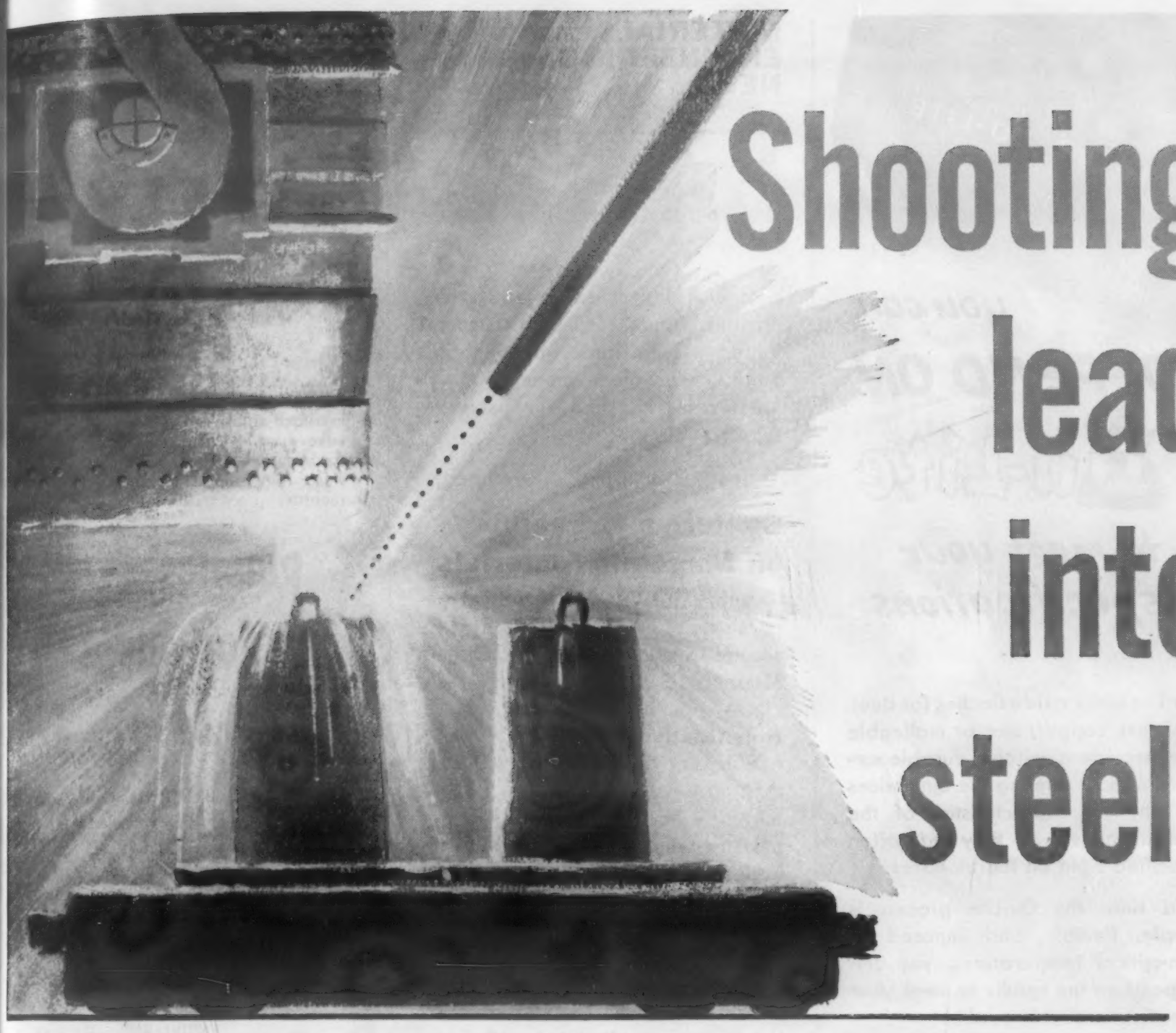
For more information, Circle No. 432



Shooting lead into steel!

Lead, strange as it may seem, imparts certain desirable machining properties to steel. Leaded steel has been found to be particularly suitable for parts going into business machines, textile machinery, hydraulic fittings, and other equipment where extensive low cost machining is required. Leaded steel in appreciable tonnages is now a part of our big steel output.

At first, the problem of introducing lead into steel and of dispersing it satisfactorily seemed insoluble. Great differences in melting points and in specific gravities tended strongly toward segregation and gas pockets when steel men tried to blend molten steel and molten lead.

Carefully graded, fine lead shot of high purity provided the answer to this production problem. By a carefully controlled process these shot are 'fired' into the stream of molten steel as it is teemed into the ingot mold.

Leaded steels provide added evidence of the usefulness and versatility of the basic metal — LEAD.

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And since the Du-Lite process is simple, flexible, and imposed at non-critical temperatures, you can depend on the results to meet your specifications—always.

Du-Lite black oxide finishes also meet govt. specs. MIL-F-13924, superseding 57-0-2C Type III Class A for steel and Class B for stainless (Type II Class B and C phosphates), and MIL-P-12011, superseding 51-70-1A para. 22.03 Class C for Copper and Copper Alloys.

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MATERIALS ENGINEERING NEWS

the cooperative groups studied, professional and technical societies devoted the largest proportion of their research and development funds to basic research. Trade associations, on the other hand, spent more money for applied research than for basic research.

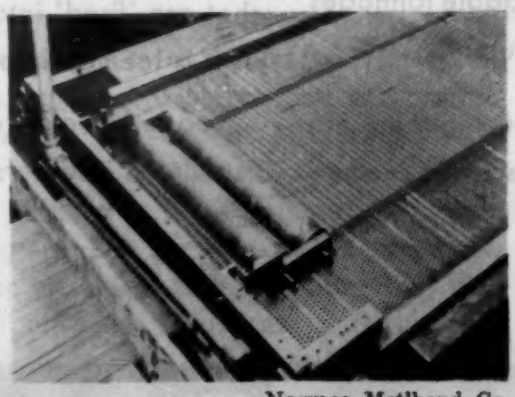
Conference, Exhibit on Magnetic Materials

Approximately 75 technical papers will be presented at the second Conference and Exhibit on Magnetism and Magnetic Materials to be held in Boston at the Hotel Statler Oct 16-18.

Subjects to be covered include: magnetic anisotropy, permanent magnets and fine particles, magnetism and physical metallurgy, losses in soft magnetic materials, ferrites, high frequency phenomena, switching devices and magnetic amplifiers, and apparatus and design.

The conference is sponsored by the American Institute of Electrical Engineers in cooperation with the American Physical Society, the American Institute of Mining, Metallurgical and Petroleum Engineers, and the Institute of Radio Engineers.

(more News on p 260)



Narmco Metlbond Co.

Core making machine continuously weaves aircraft sandwich core. The automatic machine makes possible the production of 36-in.-wide core at the rate of 1 fpm.

TAPE RECORDER CASE, designed and produced for Raytronic Laboratories, Inc., is of brown and ivory Royalite. Removable cover; ivory handle; extruded aluminum joining strip and cover edge trim. Insert and bottom of case formed in one piece. Clips, formed from waste material, hold component parts of recorder in cover.

plastics for any case...

DESIGN: From nothing more than an idea, Regal designers develop many new products and redesign outmoded units into attractive ones utilizing the plastic most suited to the end use—Boltaron, Plexiglas, Royalite, polystyrene, vinyl, fiberglass reinforced plastic, etc.

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See what adhesives are doing today!

The ribbon you see helps make this trailer home snug and weatherproof. It's an adhesive 3M Ribbon Sealer.

Fighting weather with a ribbon

Sealing weather out of trailer homes used to be a problem. Water sometimes leaked through seams, spoiling interiors, wetting insulation, corroding metal. But today this manufacturer seals all exterior lap seams with an adhesive 3M Ribbon Sealer. Since using EC 1202 he has had *no leaks* in exterior seams. This 3M product fights weather right to a standstill.

Workers easily roll this flexible, synthetic rubber ribbon along the edge of one aluminum sheet before screwing down the next. Fabric-reinforced EC-1202 is tough. It neither stretches, shrinks nor deteriorates, even during 140°F. paint drying. In fact, EC-1202 adheres so tightly it helps hold the metal together. The result—a uniform, economical, durable seal that shuts out water, dust and moisture for keeps.

Whether you face a specific problem or a general need, call upon 3M research and development. Consult your nearest 3M Field Engineer—or for literature and further information write to 3M, Dept. 69, 417 Piquette, Detroit 2, Michigan.

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New 60" x 60" tank with agitator, lined with McDanel Lining Brick. Soon to be used by one of the nation's largest manufacturers of appliances.

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MATERIALS ENGINEERING NEWS

Titanium Ingots Now up to 6000 Lb

Titanium ingots weighing 6000 lb are in production at the Titanium Metals Corp. plant, Henderson, Nev. These large ingots are produced for continuous mill hot rolling of wide titanium sheet.

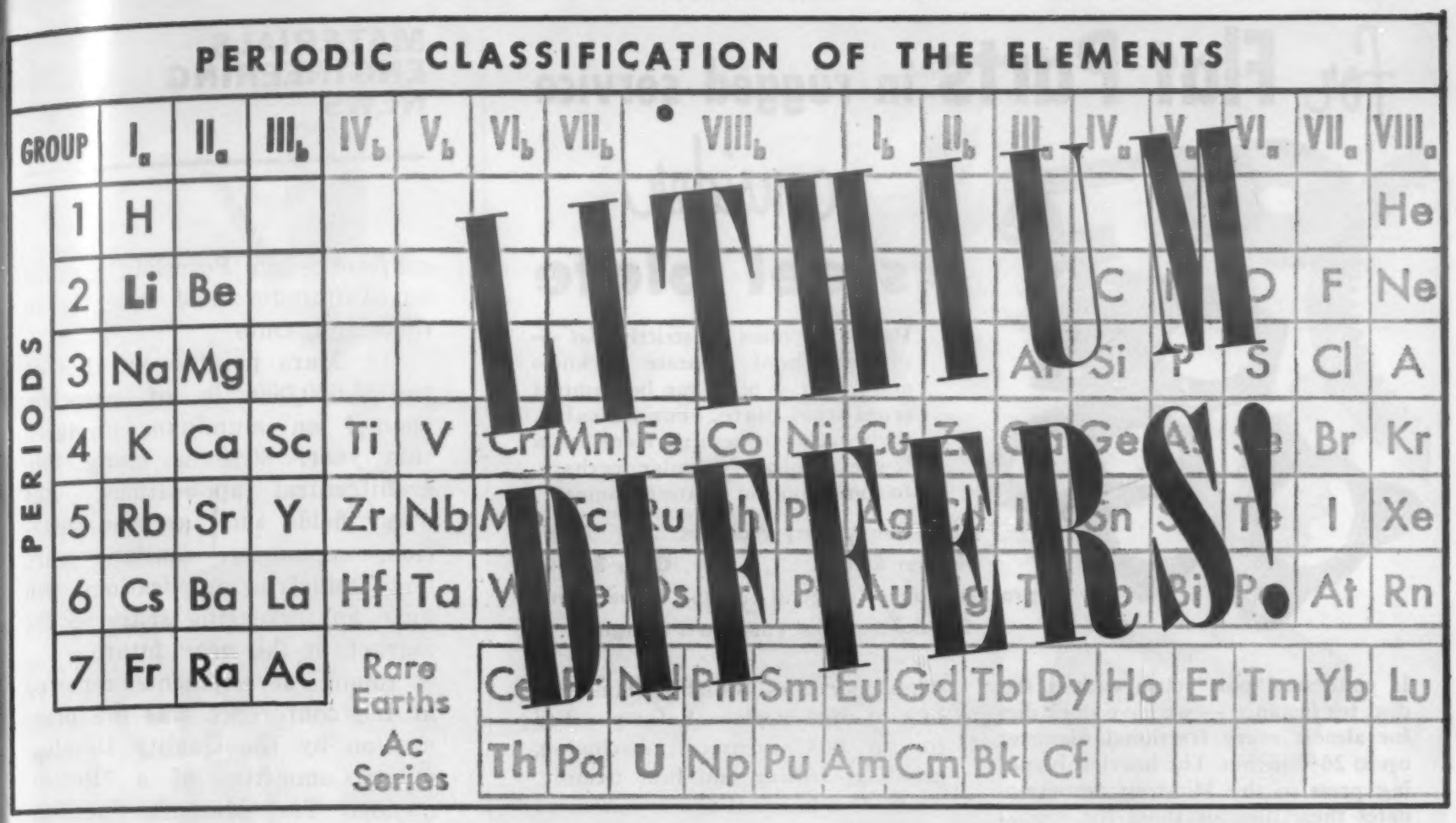
The furnace is a consumable arc, vacuum, double melting unit that pours homogeneous commercially pure and alloy ingots up to 26 in. in dia. The unit can be expanded to produce 30-in. dia ingots over 10,000 lb in weight.

Growth in Porcelain on Aluminum Seen

The next five years will show an increase of 500% in the amount of porcelain enamel on aluminum produced in this country according to P. V. Mara, speaking before the first annual

Minneapolis-Honeywell Regulator Co.

Removing enamel from hair-thin wires used in electrical coils for thermostats is accomplished by bombarding the coils with finely ground pecan shells and apricot pits. This type of grit does the job at a fraction of the cost of chemicals and other more conventional burnishing methods. Conveyorized operation permits rate of 1000 coils per hr. With routine enamel removing methods the rate was only 1000 per day.



Lithium, by reason of its atomic configuration and general characteristics, is rightfully included as the first member of Group I in the Periodic Table. A detailed study of the properties and reactions of both the elements and their compounds, however, shows that Lithium often resembles the metals of Groups II and III more closely than Group I. Following are some characteristic differences:

Lithium differs in organic chemistry . . .
because its organolithium compounds form a unique class with stability, solubility and activity characteristics intermediate between those of the Group I and Group II organometallic compounds.

Lithium also differs from the other alkali metals in that it serves as a unique catalyst for the polymerization of diolefins to materials of definite and predictable structure. It directs, for example, the polymerization of isoprene predominantly to 1,4 addition structures.

Again, recent investigations have indicated an interesting potential as a direct reducing agent in solvents such as ammonia, low molecular weight amines, and ethylenediamine.

Lithium differs in metallurgy...
inasmuch as the affinity of Lithium for oxygen, for example, is being utilized to reduce porosity in copper and copper alloy castings. Recent research has revealed that Lithium will produce brazing alloys with self-fluxing properties and increase the wetting ability of these alloys.

Lithium differs in inorganic chemistry . . .
the usefulness of Lithium Hydride and Lithium Aluminum Hydride in the preparation of other hydrides having already been widely demonstrated. Recent studies indicate that other complex hydrides prepared in a similar manner may prove to be interesting tools for research. The low dissociation pressure of Lithium Hydride at its melting point, to cite a specific example, is unique among all hydrides. LiH also has some slight solubility in polar organic compounds which is again unique among alkali metals.

Lithium differs in heat transfer . . .
based on its physical properties it has no equal as a liquid metal coolant. Due to corrosion caused at elevated temperatures by impurities in commercially available Lithium and Lithium Metal, Lithium has thus far found only experimental use.

Why don't *you* take a long look at Lithium? Its uniquely valuable differences in so many diverse fields may prove of great interest—and profit—to *you*. Write our PR&D department giving us details of the application you have in mind. Experimental quantities of Lithium Compounds are available on request.

. . . trends ahead in industrial applications for lithium

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Heavy duty Washers Rings
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If your steel part starts with a flat disc, for instance — we have stock dies for almost every fractional diameter up to 26½ inches. The heaviest blanking press in the Mid-west accommodates these dies, or those for special shapes to your design, stamping from plate 3/16″ to 1-1/4″ thick, depending on area.

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MATERIALS & METHODS
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MATERIALS ENGINEERING NEWS

conference on Porcelain Enamel on Aluminum held recently in Cleveland, Ohio.

Mr. Mara pointed out that of the 3,600,000 lb of porcelain enamel on aluminum produced this year, 80% is going into architectural applications. But other fields such as transportation, appliances, sanitary ware and industrial applications will have an increasing share of the market in the near future.

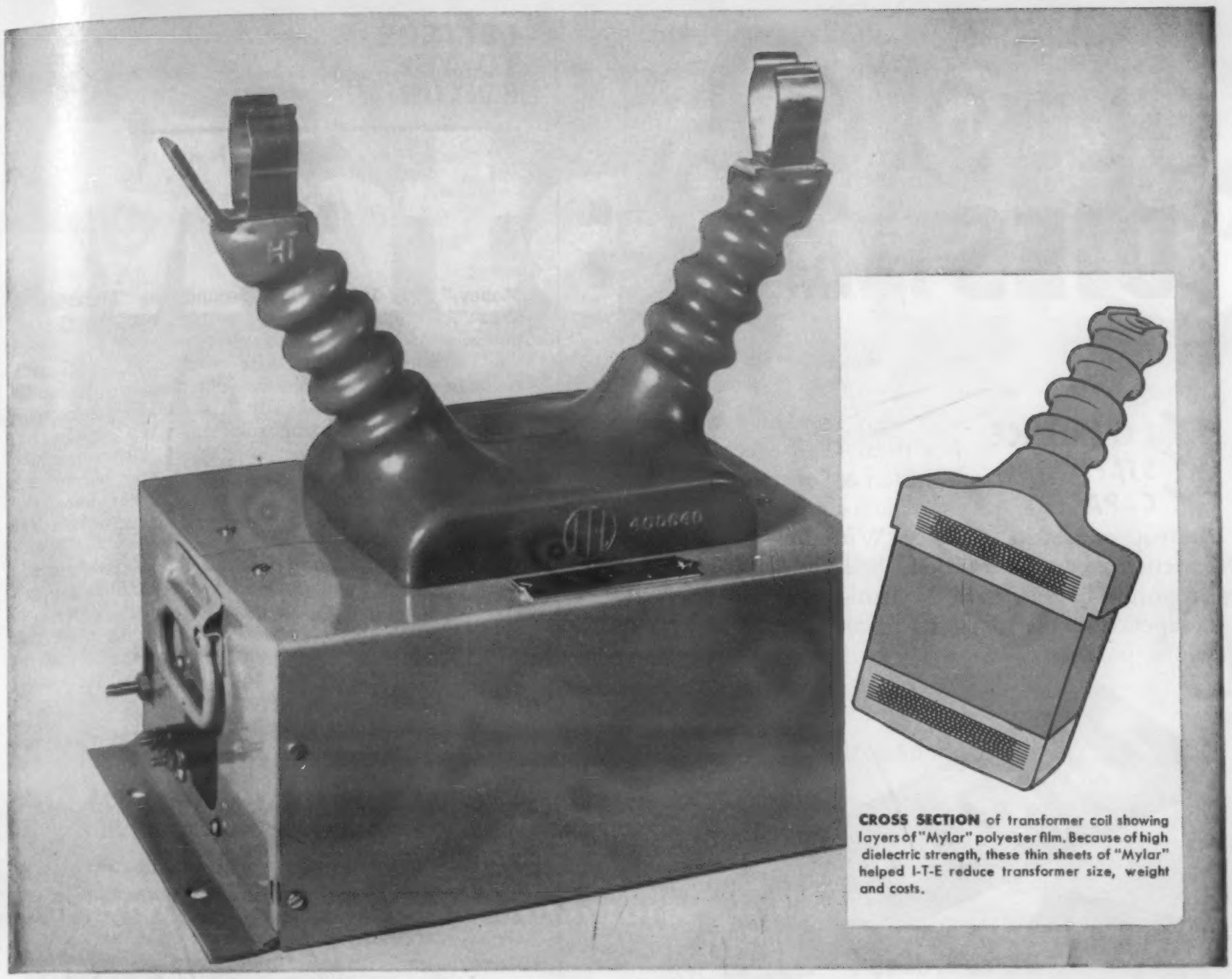
Among developments reported at the conference was the preparation by the Quality Development Committee of a "Recommended Test Methods Specification for Porcelain Enamel on Aluminum" and a tentative specification booklet for processing methods. The Cost Analysis Committee is now working on a survey to arrive at average figures for each step in the porcelain enamel on aluminum operation.

Molybdenum Alloys Will Be Discussed

A two day symposium on the technology of molybdenum and molybdenum base alloys is being sponsored by the Office of Naval Research Sep 18 and 19 in Detroit.

Some 15 papers will be presented dealing with molybdenum as a structural material, preparation and fabrication of molybdenum and its alloys, metallurgy of molybdenum and molybdenum base alloys, and molybdenum in gas turbine applications. The meetings will take place in the Rackham Memorial Building. Further information can be obtained from J. J. Harwood, head, Metallurgy Branch, Office of Naval Research, Washington 25, D.C.

Hydrogen in Titanium
Coming in October
A concise report on what you should know to avoid difficulties.



CROSS SECTION of transformer coil showing layers of "Mylar" polyester film. Because of high dielectric strength, these thin sheets of "Mylar" helped I-T-E reduce transformer size, weight and costs.

*MYLAR** helps reduce size, weight and cost of transformers for I-T-E Circuit Breaker Co.

"By using 'Mylar' as the insulating material, we've been able to reduce the size, weight and cost of our potential transformer without changing its rating," reports the I-T-E Circuit Breaker Company, Philadelphia. "That's because 'Mylar' has higher dielectric strength in thinner gauges than the material formerly used."

All leading electrical manufacturers are now using Du Pont "Mylar". They've found that "Mylar" has greater dielectric strength in thinner gauges than most known insulating materials. At the same time, this tough, flexible film is resistant to moisture, oils, chemicals and solvents. There's extra thermal stability with "Mylar", offering a possible service range from -80° to 300°F.

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LETTERS TO THE EDITOR

continued from p 14

Money," May 1956, p 114. Second, the "Materials at Work" section, May 1956, p 119, relating the experience of Douglas Aircraft.

Information from our customers continually reverifies that titanium does not dissolve at a measurable rate when anodically protected in any chromic and sulphuric anodizing solutions. We supply titanium wire and strip, not only to the direct user who uses the titanium rack in his own shop, but to rack manufacturers who supply many other anodizers. We have never had a complaint of unsatisfactory performance. . . .

We feel that both aluminum and titanium will have a place as anodizing racks; aluminum for special racks which will be used once or twice; titanitum for standard racks which will be used over and over, where the life span of the rack and the elimination of stripping between cycles will easily justify titanium's initial cost.

A. G. CATERSON, Sales Engineer
Rem-Cru Titanium, Inc.
Midland, Pa.

To the Editor:

Mr. Caterson is correct. Titanium may be used and is being used successfully on a commercial basis. Other metals also may be used such as platinum, rhodium, etc. We did not wish to imply in the article that no other materials could be used; however, aluminum is used to the greatest extent on a commercial basis. There are certain commercial applications where racks are quite complicated and expensive. In many of these cases, titanium despite its higher cost is the best selection for rack components since it is unaffected by any of the conventional etches used prior to anodizing and it is unaffected by the anodizing operation itself.

R. V. VANDEN BERG
Alcoa Process Development Labs.
Aluminum Co. of America
New Kensington, Pa.

U.S. and British specs

To the Editor:

We need information concerning the comparison of British and U.S. specifications on aluminums, stainless steels, steels and plastics.

Do you know of any such cross index of specifications for materials?

R. GORDON, Assistant Chief Engineer
Aircraft Engine Projects
Aerojet-General Corp.
Azusa, Calif.

There is, unfortunately, no cross index of British and U. S. materials specifications available. Two comparisons of specifications for aluminum alloys have appeared in this magazine: Apr 1954, p 135, and Oct 1955, p 137. For further information, we suggest contacting the British Standards Institute and the American Standards Assn.